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PRESIDENT'S MESSAGE

Frank F. Groseclose

"Now is the time for all good men to come to the aid of their"—American Institute of Industrial Engineers.

Two very important events are on our immediate horizon. (1) Election of National Officers, and (2) the National Convention in Louisville. With reference to the National Election I quote two sections from our Constitution:

"Section 12—A slate of officers, excluding the regional vice-presidents, executive secretary and assistant executive secretary, shall be drawn up yearly by a nominating committee consisting of the vice-presidents or their appointees. At least two and not more than three names shall be put up for each office. Officers shall be elected by a mail vote of the entire regular membership. Ballots will be distributed by the Executive Secretary and will be counted by the Executive Secretary and a Tellers Committee appointed by the President.

Section 13—The Vice-President for each region shall be elected at the same time as the other national officers by the entire regular membership of the region in which he is to serve. At least two and not more than three names for this office shall be drawn up by a nominating committee composed of the chapter presidents and the delegate-at-large from the region. Ballots will be counted as described above. The retiring Vice-President will be responsible for conducting the nominations and for reporting the results to the Executive Secretary in time for inclusion on the ballot."

Each of us as individual members has the privilege, and I might add the obligation, of sending in immediately, to the proper persons, the names of those individuals considered to be the best available men for the various jobs. The proper persons to send nominations to are as follows: (1) Nominations for the next

(Continued on Page 20)

Project Progress Analysis and Control

By J. T. Elrod

Professor & Chairman of Industrial Engineering Department, University of Houston

Industrial Engineers are thoroughly aware of the large amount of research, thought and gathering of data directed toward the establishment of measures of performance for repetitive and intermittent production operations. The result is the development of standards, usually in units of standard hours or minutes per piece or 100 pieces, or other convenient measures which apply to the items produced. These data are used (among other things) in establishing production schedules. On the other hand, we find many instances of the project, or "one-time," type of job. In some industries such as the construction and process industries for example, a majority of the work performed is of this type. (A start has been made toward the establishment of elemental time standards and "standard data" in these industries, but only a start.) However, in any type of industry, including continuous and repetitive production industries, there are always "projects" to be accomplished. Examples of the type of project referred to are the installation of a heat treat furnace, the moving of a department from one location to another, or the actual engineering required to put a new model into production.

Planning for such projects varies in degree, depending on a number of factors, from merely "guesstimating" the dollar expenditure for the project, to rather elaborate plans consisting not only of budgetary controls, but also of Gantt charts with bars showing starting and finishing dates for sequential phases of the project. Progress in each of these phases is frequently measured on the basis of percent completed (usually a field estimate by the supervisor), or, if units are involved, on the basis of number of units completed. An example of the latter would be in the case of inventory record cards to be prepared in connection with the production of a new model. It will be noted that usually in analyzing the progress of a project (or a phase of a project) a straight-line relationship between percent complete or quantity complete, and time, is assumed. That is, if four weeks is allotted to a particular job, then 25% completion is expected at the end of one week, 50% in two weeks, 75% in three weeks, etc. The same type of relation is usually planned for projects involving units, such as the inventory record cards referred to above.

It will be the purpose of this paper to show that progress on project type jobs does not follow (generally) a straight-line relationship between completion rate and time. That is, 50% of the job completed does not necessarily coincide with the half way mark on the time scale. Further, that such departures from a straight-line relationship are logical and natural, and should be recognized as such. A recognition and understanding of the **curvilinear** relationship will aid greatly in the planning and control of a project, resulting in overall improvement in efficiency. It logically follows that the nature of the work involved in the project will determine the shape of the progress curve, and that performance at various stages can be measured against this curve. Certain industries, notably the aircraft frame industry, uses this method to allocate man-hours to specific job orders by plotting a sine curve (the portion between $-\frac{\Pi}{2}$ and $\frac{\Pi}{2}$ radians) with time as the abscissa and cumulative man-hours as the ordinate.[1] In general, it has been found that projects do follow a progress curve more or less on the order of the shape of a sine curve. However, it should be pointed out that there is no angular relationship between the variables; it just so happens that projects follow the general trend indicated by a sine curve, and a sine curve can be readily plotted.

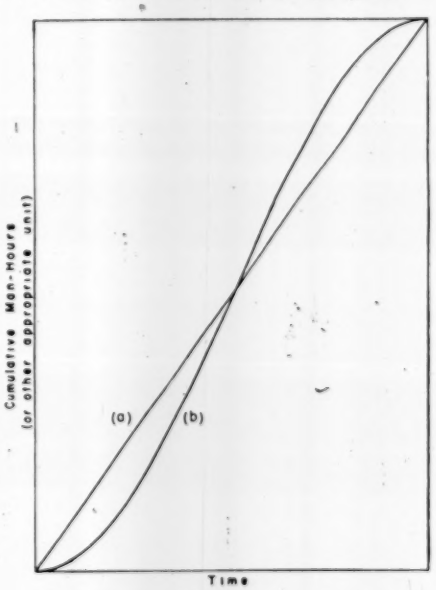


Figure 1

The question arises as to how a curve or set of curves might be developed for a specific industry, company or type of project. It can be expected that the project progress curve will have the general characteristics of a slow start, a middle period of rather consistent progress, and a tapering off at the end. (All curves referred to are **cumulative** on the ordinate in appropriate units, and a time scale on the abscissa. See Figure 1.) However, the various factors influencing progress will determine the exact shape of the curve.

Before discussing the question of curve development, it might be well to present an example or two to illustrate types of projects and how progress fluctuates. In a large manufacturing company the Industrial Engineering Department was charged with preparing certain forms relative to starting production on a new model. Approximately 360 parts were involved and one copy per part of each particular form had to be prepared from data furnished by the engineering design group. In order to accomplish the work within the specified time period, a schedule of 18 forms per day was set. For a period of nearly two weeks the work fell progressively behind the "schedule." This, of course, was noted and additional man power was shifted to the operation to bring it up to schedule. This same type of fluctuation repeated itself twice before the completion of the job.

To approach projects of this nature more realistically would involve an analysis of such factors as optimum number of people that can be assigned or are available for the project, learning or "breaking-in" time required for key person or persons, rate at which additional people can be assimilated on the job, coordination with progress of other work, standard rate of production after learning or "breaking-in" period, and final stages of the project to allow for checking, correction, stragglers, etc. Thus instead of a schedule of 18 forms per day over the entire period, the schedule would start with, say, five and increase at an accelerating rate to say, 25 per day, and then toward the end of the period allotted, taper off to a low figure again. Man-power could be planned in accordance with these factors. Such planning would allow for the most efficient utilization of personnel, provide a realistic basis for judging progress, and improve coordination of all operations within the department and between departments. In his excellent book "Engineering Organization and Methods," Mr. James E. Thompson[2] gives some illustrations of the progress curves resulting from engineering projects in connection with aircraft design. These show the trends referred to above.

Another example of an entirely differ-

(Continued on Page 18)

[1] Berghell, A. B.
(1) Berghell, A. B., *Production Engineering in the Aircraft Industry.* New York: McGraw-Hill Book Company, 1944.

[2] Thompson, James E.
(2) Thompson, James E., *Engineering Organization and Methods.* New York: McGraw-Hill Book Company, 1947.

Editorial Comments—

The Nature of Industrial Engineering

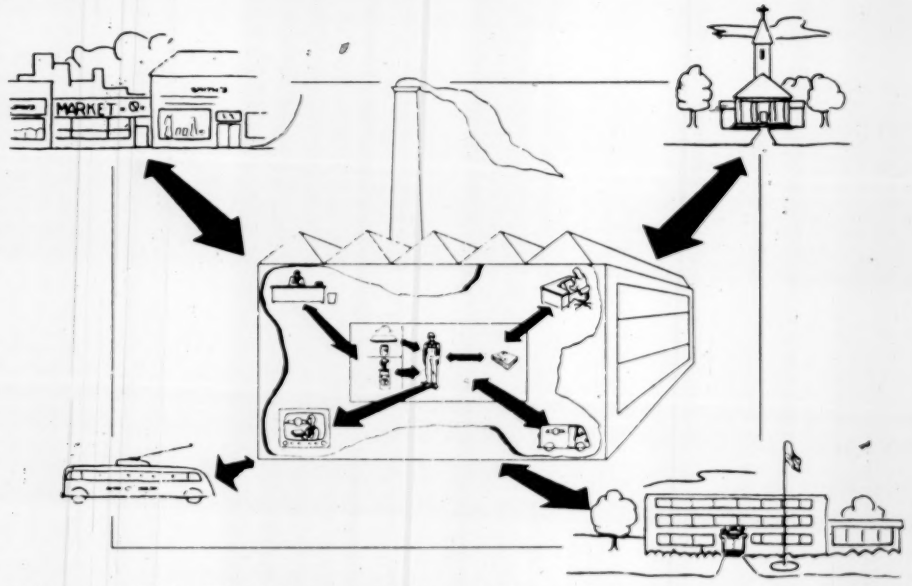
By Robert N. Lehrer, Editor-in-Chief
Associate Professor of Industrial Engineering, Georgia Institute of Technology

Many times we hear comments about our Profession that are somewhat confusing, and perhaps a bit uncomplimentary. Industrial Engineering has been defined in many ways, but it is still one of the most misunderstood fields of engineering. The various definitions still leave room for confusion in our own thinking and lead to misconceptions about our work. As an Industrial Engineer I am proud of my profession. Proud of the past accomplishments, and certain that future accomplishments will be noteworthy. I do, however, feel that we should take stock of our basic concepts and their relation to the problems with which we work. By so doing we should achieve a more uniform interpretation of our main objectives and the manner in which we can best achieve them.

The engineering basis for Industrial Engineering, and the differences between Industrial Engineering and the classical fields of engineering are two factors that should be clearly recognized. The Industrial Engineer is first of all an engineer. But he is much more than just an engineer, for the problems with which he deals are different than those of the classical engineer. The Industrial Engineer is obliged to consider the human factor as a basic ingredient in most all of his problems. The Industrial Engineer is charged with the coordination of men, materials and machines to achieve a desired result in an optimum manner. This is illustrated in the sketch by the inner area showing materials, man, machine, and the resultant product.

Some Industrial Engineering problems may be very technical, and require a high degree of engineering skill for proper evaluation and design of the inanimate aspects of a process or operation. On the other hand, some of our problems are not too involved as far as the technical factors are concerned. In both situations the human factor is present, and it should be dealt with in a systematic and factual manner. Consideration of the human factor often requires using values other than cost. It requires considerably more than just understanding "human nature." It requires the use of knowledge from the fields of the human and life sciences.

Industrial Engineering problems, by virtue of including the human factor along with materials and machines, are influenced by all the things that influence the human as an individual and as a member of a social group. The problem illustrated in the inner area of our sketch shows the combination of materials and machinery with the aid of a man. This produces the desired product. The man is influenced by the materials, machines



and the product. This in turn modifies the manner in which he does his job of actually combining the materials and using the machinery to produce the product. The immediate problem is further complicated by the reaction of the individual to the social or institutional factors that are present within the organization. Not only is the man influenced by the forces, but he also helps to modify them for he is an active part of the organization. The individual work situation is influenced by general social and economic forces that arise outside of the production organization. These forces tend to modify the immediate situation with which we must deal, but the individual situation tends to modify these external forces. The proper solution to a man, materials, and machine problem requires careful consideration of all of the factors just mentioned. This must be done in addition to the normal "engineering" involved.

Industrial Engineering problems, viewed within the frame of reference just outlined, require the consideration of many factors that are not directly within one individual work situation, but which should be considered if Industrial Engineering is to be of maximum utility. The basic concepts of Industrial Engineering were formulated many years ago. They are continually being reinforced. These concepts require a broad view of the application of Industrial Engineering with full recognition of all facets of the problem. Our work is becoming more and more complex, and we know that we need better solutions to our problems. This requires ever increasing knowledge for the performance of our duties, and increased use of scientific knowledge drawn from the fields of the physical sciences, mathematics, and the human and life sciences. We must design our work situations with careful consideration of each factor and force involved.

The engineering basis for Industrial Engineering revolves around the design of work situations. This can be illustrated by examination of a definition of Professional Engineering, as stated by Dean R. L. Sweigert of Georgia Tech's Graduate Division.

> Professional Engineering involves *research* leading to design, *development* leading to design, or *design*, based on the physical sciences, mathematics, mathematical statistics, or the human and life sciences.

This definition places great emphasis on the design aspects of engineering. It is quite possible that some operational activities are still within the intent of the definition, if these activities require considerable design knowledge for their performance. This could also be true for service, repair or maintenance duties.

Now let's define Industrial Engineering and see how it compares with the above definition.

> Industrial Engineering is the *design* of situations for the useful coordination of men, materials and machines in order to achieve desired results in an optimum manner. The unique characteristics of Industrial Engineering center about the consideration of the *human factor* as it is related to the technical aspects of a situation, and the integration of all factors that influence the overall situation.

This type of Industrial Engineering, with a strong emphasis on design, is not currently practiced by all individuals bearing the title "Industrial Engineer." However, it is the type of Industrial Engineering most needed for effectively solving Industrial Engineering problems.

TIME STUDY RATING PROCEDURES

By Adam Abruzzi
Associate Professor, Department of Industrial Engineering, Stevens Institute of Technology

THE FUNDAMENTAL WEAKNESS OF SUBJECTIVE TECHNIQUES

Rating is admittedly the most controversial and weakest aspect of current time study. The reason is quite clear: all rating procedures require the subjective evaluation of a worker's performance in terms of a subjectively defined standard —the hypothetical "normal" worker. Some time study writers are somewhat self-conscious about this fact. Carroll, for example, says that a mathematical solution to this problem would have been ideal.[1] But, he adds, it is apparently impossible to estimate by mathematical methods the relationship between what did happen and what ought to happen.

Mundel expresses much the same viewpoint.[2] He says:

> Mathematical methods propose to analyze statistically the distribution of operator times and to obtain mathematically a rating or correction factor. However, there are so many variables affecting these times that the mathematical sorting out of the operator's skill, aptitude, pace, exertion, capriciousness and so forth, from the normal job variation has never been successfully done.

Careful reflection shows that two conclusive objections can be raised to this viewpoint. Even if it were true that statistical or, in general, objective techniques could not be applied successfully to these problems, it would not necessarily follow that subjective techniques could be. Thus, the fact that no statistical technique has yet been devised for predicting stock market variations does not mean that subjective judgments will be any more successful.

The second objection is even more convincing. It is impossible to obtain accurate (valid) and precise (reliable) results if objective techniques are not available. This is why Shewhart says of the subjective approach:

> We would have to accept a result simply on the basis of the authority of the experimentalist. Then we would face the difficult task of determining the ultimate authority. Such a method is certainly not scientific, nor does history reveal much ground for the belief that it is a method that can be relied upon to give satisfactory results.[3]

Another misconception about subjective techniques like rating is popular among time study writers and others. Though they may be poor intrinsically, subjective judgments are considered to become more accurate and more precise simply because the judgments of several observers are pooled.[4] The simple fact is, however, that the repeated use of any given technique cannot make it more accurate or more precise than it was originally. As an instructive analogy, rolling a large number of biased dice doesn't make the dice any less biased.

The subjective approach inherent in time study rating can also be criticized effectively for other important reasons, such as the vague, ambiguous, and frequently circular definitions of the hypothetical "normal" worker. Details on these questions need not be considered here; they are available in much of the critical literature, notably the works of Gomberg and Kennedy.[5] The net result, as the present writer shows elsewhere, is that it is impossible to determine by scientific means how much time an operation ought to take, which is the primary objective of time study rating.[6]

The fact remains, however, that rating is an integral component of the current time study process. For that reason, a more specific and detailed investigation of this subject is in order, particularly the assumptions and techniques used. To simplify the discussion, we will confine our attention to the two rating procedures used most often in practice, the so-called LMS leveling, and the "effort" rating procedures. This is really no limitation, for most of the arguments presented will apply equally well to other rating procedures.

THE LMS LEVELING PROCEDURE

Lowry, Maynard, and Stegemerten, the originators of this procedure, consider four factors to be relevant: skill, effort, consistency, and conditions.[7] Like most other aspects of the rating approach, these factors are defined subjectively and ambiguously. Thus, effort is defined "simply as the will to work . . . It is not related to the amount of foot-pounds of work exerted during a given period, but rather to the zest or energy with which the task at hand is undertaken." The authors also define, again subjectively, six classifications for the four factors considered, each with an arbitrarily-established numerical value. For example, we are told that "the average effort is a little better than the fair effort and a little below the good."

Let us now look into some of the assumptions inherent in the LMS leveling procedure. The authors assume, without any supporting evidence, that the entire (human) population has a normal distribution with regard to these four factors (i.e., when their numerical point values are added). They also find it convenient to assume, also without supporting evidence, that the ratio between the extremes in this population is about 6 to 1. They make the further unsubstantiated assumption that the working subpopulation also has a normal distribution with regard to these factors, but with the much smaller ratio of 2.76 to 1 between the extremes. The justification given is that the working subpopulation is made up only of individuals with "marked ability to perform the work at hand."

This is not only an unsupported assertion; it also directly contradicts the eligibility requirements for industrial workers established by the authors themselves. According to their classification system, a worker who makes many errors, lacks coordination, is a misfit for the job, obviously kills time, resents suggestions, appears lazy, and is unable to think for himself would be accepted as a legitimate member of the working population; he can hardly be considered to have marked ability to do industrial work.

In their summary, the authors state that "properly applied, with an understanding of the principles on which they are based, this procedure will be found to give satisfactory results." This statement suggests that any one will obtain satisfactory results with their procedure unless he doesn't understand the "principles" involved. In this way, they define away every major problem of verification, including how one is to determine what is a "satisfactory result."

THE PRESGRAVE "EFFORT" RATING PROCEDURE

By far the most popular rating procedure is Presgrave's "effort" rating procedure.[8] This procedure considers just one factor: the relative pace of the worker defined in terms of the hypothetical "normal" worker. Here, then, the worker's relative pace is evaluated numerically on a scale with a base value of 100 percent, which is considered to be the "normal" pace. It might be noted that Presgrave, like numerous others, rejects skill as a rating factor, basing his argument in part on the ground that skill is difficult to define and measure.

In developing his procedure, Presgrave also assumes without supporting evidence that industrial workers have a normal distribution. This normal distribution differs from that of Lowry, Maynard and Stegemerten in that it refers only to the relative pace of the workers and has a ratio of 2.25 to 1 between extremes. This ratio value was obtained largely from certain data on physical characteristics originally developed by Wechsler, which will be considered a little later.[9]

Like Carroll, Presgrave says that the ideal situation would be to rate—relative pace, in his case—by using statistical techniques. But since none seem to exist, he, too, reconciles himself to the use of subjective techniques. Despite this, he agrees with almost all other time study writers in believing that rating results can be "accurate." His estimate is that ratings can be "accurate" to plus or minus five percent.

THE RATIO BETWEEN EXTREMES APPROACH

Fundamental to both the LMS leveling procedure and the Presgrave "effort" rating procedure is the belief that the

ratio between the extremes in workers' production rates is quite limited: 2.76 to 1 in the former case and 2.25 to 1 in the latter case. Let us examine these ratio values carefully, first the 2.25 to 1 value adopted by Presgrave.

To understand his position fully, we should amplify Presgrave's views on this subject.[10] He begins by pointing out that "David Wechsler, with much supporting evidence, advances the hypothesis that for most human capacities not inhibited by special circumstances, the range value will not exceed 2.718 to 1." Presgrave also makes empirical criticisms of the data of Clark Hull, who presents some competitive data indicating the ratio between extremes in production rates for the average vocation is between 3 to 1 and 4 to 1.[11] On the basis of these criticisms, he proceeds to discard what he considers to be an unacceptable portion of Hull's data; the result is that Hull's remaining ratio values "are quite close to those of the more fundamental motor capacities as reported by Wechsler."

Presgrave also introduces a table published by Barnes, giving the average production rates of 120 experienced lathe operators in a single day's trial. He considers this case, with its ratio of 2.04 to 1 between sample extremes, sufficient to confirm Wechsler's results on an industrial level. His final conclusion, then, is that "the 2.25 to 1 ratio for a single human capacity such as effort" is reasonably dependable.

It should be mentioned that the few writers who accept neither the LMS leveling procedure nor the Presgrave "effort" rating procedure nevertheless endorse the viewpoint that the range of human capacities and, particularly, the range of production rates is quite limited. As a representative example, Mundel asserts that "with any physical attribute, the ratio between the best and the worst is seldom greater than 2 to 1 with few cases of even these extremes."[12]

As we have already seen, Lowry, Maynard and Stegemerten also postulate that production rates have a limited range, with a ratio of 2.76 to 1 between extremes. In their case, however, none of the basic data has been published, and we are told only that these data were based on the time study results obtained by 175 different observers.

THE TOLERANCE LIMIT APPROACH

The ratio between extremes approach has two decisive shortcomings. First, it assumes that the extremes obtained in a sample of a limited number of readings is exactly the same as the "true" extremes that would be obtained if all the individuals in the population were observed. This is emphatically not the case, for the size of the sample plays a fundamental role in this and all other problems where sample values are used to estimate population values. This question, however, was completely overlooked by Wechsler and Hull as well as by those using their results.

There are formidable mathematical difficulties involved in developing a theory relating sample extremes to population extremes. However, an adequate theory for present purposes does exist in the tolerance limit approach developed by Wilks.[13] According to this approach, the question we ask is: How large a sample is needed to be sure that the probability is a, say, that a minimum proportion b, say, of the population will fall between a pair of observed sample extremes.

In practice, we must first decide on the magnitude of a, using as a criterion the empirical consequences of making an erroneous statement. Although the tolerance limits approach can be used with any probability value, the two common values of 99 percent and 95 percent considered below should be adequate for most problems of this kind.

Another advance decision we must make is the minimum population proportion b that we want the sample extremes to cover. Again the decision must be made on empirical grounds. Since we want the sample extremes in these problems to cover as much of the population as possible, a reasonable value for the minimum proportion to be covered would seem to be 98 percent—the value used in the studies described below.

Representative data recorded by Hull and by Wechsler were subjected to the tolerance limit technique.[14] Some of the results are presented in Table 1; these results were selected so as to point up the inadequacy of the ratio between extremes approach.

We should first notice that two minimum proportion values are reported in each case. Using hemoglobin content as an example, we can interpret these values empirically as follows: the probability is 95 percent and 99 percent, respectively, that at least 82 percent and 78 percent of all people have hemoglobin contents falling between the reported extremes of 14.39 and 18.03 grams per 1000 cubic centimeters.

Using the suggested b value of 98 percent as a criterion, we find that the minimum proportions covered are unacceptable in each case tabulated. The table also shows us that the sample size is the decisive factor in determining whether the minimum proportion is acceptable. In particular, the larger the sample size, the larger is the proportion covered by the sample extremes. This explains why none of the ratio values recorded is acceptable; all of the sample sizes are quite small. It turns out that sample sizes of 500 or more are needed to insure a minimum population coverage of 98 percent, given a probability value of 99 percent.

This discussion clearly shows that the ratio values, reported by Hull and Wechsler and used so heavily by Presgrave and others, may be quite erroneous. We've already mentioned that the data and the sample sizes used by Lowry, Maynard and Stegemerten have not been published, which prevented making an analysis of their 2.76 to 1 ratio value. In view of our discussion, however, we must conclude that their ratio values are also likely to be erroneous. Since such ratio values are used as a base for the corresponding rating procedures, the rating procedures themselves must be concluded to be of doubtful validity.

To make legitimate inferences, it will be necessary to apply the tolerance limit technique described here to a comprehensive body of data. These data should meet all the requirements of that technique, especially concerning the sample size. Besides, the data should be based primarily on industrial production rates rather than on other human characteristics.

Presgrave, as well as Lowry, Maynard, and Stegemerten, also assume that workers' production rates have a normal distribution. Presgrave's assumption is completely unjustified since he bases his argument on the Hull and Wechsler data, which are not normally distributed (as Wechsler himself points out). As for Lowry, Maynard and Stegemerten, no supporting data is given to support their assumption. These questions, however, cannot be treated in such a haphazard manner, for the results obtained depend critically on what assumptions can reasonably be made about the form of the distribution. The tolerance limit technique can be applied in any case, and it is always prudent to make no unwarranted assumptions which may effectively destroy the empirical usefulness of the results obtained.[15]

TABLE 1

Wechsler's Data

Characteristic	Sample Size	Ratio of Extremes	Min. Prop. b Covered Prob. Value a	
			95%	99%
Calcium in Spinal Fluid	49	1.16 to 1	85	81
Hemoglobin Content	40	1.25 to 1	82	78
Pulse Rate	94	1.66 to 1	92	90

Hull's Data

Productivity Index	Sample Size	Ratio of Extremes	Min. Prop. b Covered Prob. Value a	
			95%	99%
Case I	26	1.5 to 1	83	79
Case II	32	1.5 to 1	86	82
Case III	32	1.8 to 1	86	82

EXPERIMENTAL EVIDENCE ON RATING CONSISTENCY

Time study writers are quite ready to quarrel about which rating procedure should be used. But they show a remarkable agreement about the "accuracy" of these procedures, which is usually claimed to be of the order of plus or minus five percent. Another point of remarkable agreement is that none of the claims is supported by validated experimental evidence. Thus, time study writers and observers alike rarely, if ever, define or make a distinction between accuracy and precision. One of the consequences of this is that the claims of "accuracy" have nothing to do with accuracy. They are concerned instead with precision, and only precision.

When one looks behind these claims, he finds that they refer to the precision of the rating results obtained by one observer or a group of observers on the same operation. The claims, then, refer to the ability of one or more observers to duplicate their rating results—which is what is meant by precision. Now, as we shall see, there can be no such thing as the precision or—to use the more connotative term—the consistency of a given rating procedure, since the results obtained depend crucially on the observer. We are concerned instead with the consistency of one or more observers in using that rating procedure.

With this in mind, let us examine some experimental results. Rogers has reported the results of a test on the consistency of rating of individual observers (i.e., the ability of individual observers to reproduce their rating results).[16] What Rogers did was to have each observer time and rate several operators doing a simple card-dealing operation, using the LMS leveling procedure. Then he plotted a point for each pair of time and rating values.

Now if the observers had been consistent in their ratings, the plotted points would have fallen on a straight line. However, Rogers found that many of the plotted values fell outside of the plus-or-minus ten percent interval constructed around the fitted straight line. Yet this was a very simple operation, with none of the dynamic and subtle work characteristics of modern industrial operations. It is no wonder, then, that Rogers concluded that "it is doubtful if the confidence of many time study men, in their own ability to rate operator performance consistently, is very well founded."

A number of other critical students likewise dispute the claims made regarding the consistency of rating. To take one example, Quick, Koehler and Shea describe a study in which 100 time study men from different industries were asked to establish a production standard for a simple bolt and washer assembly from a film record.[17] In all, 62 different standards were recommended, with an overall variation of 61 percent. This result is used by these writers to bolster their argument that rating is one of the weakest aspects of time study.

TABLE 2

		Element #1		Element #2	
Observer	Operator	Mean Value	Rated Value	Mean Value	Rated Value
1	1	16.3	20.4	10.0	12.5
1	1	14.3	15.7	8.8	9.7
1	1	19.0	22.8	9.8	11.8
1	2	20.2	24.2	11.1	13.3
1	2	22.7	27.2	11.1	13.3
2	1	18.5	23.1	9.3	11.6
2	2	20.6	22.7	10.0	11.0
2	2	19.7	23.6	11.4	13.7

A number of tests of consistency in rating were also made by the present writer. These tests were intended to determine how consistent one or more time study observers were in rating different operators assigned to the same industrial operation. All the time study observers had previously had at least one year of experience and used the Presgrave "effort" rating procedure. Here, in Table 2, is a typical set of results obtained on two elements of a garment-sewing operation. These studies were made by just two observers on just two operators within a period of two days.

One of the principal claims regarding rating procedures is that rated times should not vary by more than plus-or-minus five percent on a single operation. Yet an empirical study of the above results show that:

1. Neither observer was plus or minus five percent consistent in rating just one operator, let alone in rating the two operators. Observer 1 was poorer in this respect, partially, it would appear, because he had two additional opportunities to be inconsistent.
2. The rated values of the two observers were quite inconsistent, both in rating one operator and in rating the two operators.
3. The rated values seem to be closely related to the observed mean values. Yet rating theory insists that they represent the times to be expected from a hypothetical worker, which means that the rated values should have no such relationship to the mean values.
4. The variations among the mean values are somewhat smaller than the variations among the rated values—a strange result in view of the fact that rating procedures are supposed to reduce the observed mean values to a unique value. This means that in some cases, rating procedures not only do not yield consistent results; they actually introduce an additional major source of inconsistency into the time study process.

A somewhat similar piece of experimental evidence was obtained by Cohen and Strauss.[18] In this case, film studies were made of 21 experienced operators working on a man-controlled operation. Each operator was then rated by three trained observers using the LMS leveling procedure. When their pooled rating judgment was applied to the observed times, it was found that the rated times varied from 59.04 to 124.70 film units ($\frac{1}{16}$ of a second). This hardly confirms the claim that rating procedures cancel out differences in operator performance and reduces them to a unique value characteristic of a "normal" worker.

We should also keep in mind that these were pooled ratings. This means that differences in judgment among the three observers were eliminated, and the test was in effect just a test of the consistency of one observer. If the differences among the observers had been taken into account, the reported variations in the rated results would have been even greater.

The preceding material does not imply that consistent ratings cannot be achieved, for it is certainly possible to train a group of observers to evaluate performances in the same way. What it does imply is that consistency is sometimes not achieved, even by a single observer evaluating just one operator. The fact is—and this point is not even recognized in literature—that it is meaningless to talk about the consistency of a rating procedure. As we've already seen, a rating procedure is only as consistent as those who use it; we can determine only how consistent an observer or a group of observers is with regard to a given operator or group of operators.

THE PROBLEM OF ACCURACY IN RATING

Even if we were to assume for argument's sake that rating procedures are consistent, we still wouldn't be very far. We still have the problem of rating accuracy, a far more important property than rating consistency. Thus, a reasonable amount of diligence, accompanied perhaps by vocational pressures, could persuade any given group to evaluate performance in essentially the same way. This certainly does not mean that the evaluation is a correct or an accurate one.

But no independent evidence has ever been produced showing that rating procedures are accurate. This is quite understandable inasmuch as accuracy is not even defined in most of the current literature. To determine the accuracy of a rating procedure, it is necessary to have an independent criterion to test the rating factors used. To take an example from the physical sciences, tensile strength values can be estimated from

(Continued on Page 17)

Current Trends in Organization

By Walter B. Schaffir
Administrative Engineer, Sperry Gyroscope Company

Like many other terms in the management vocabulary, the term "Organization" has been somewhat discredited in the mind of some people. They feel that organization implies regimentation, bureaucracy, rigidity, stifled initiative, and restrained flow of communication; they hold, in fact, that in a group of mature people one can do well without it. The blame for this may be placed both on the overemphasis on the mechanical aspects of organization theory and on occasional abuse by people who forget that formal organization is not a substitute for good human relations. Like any other tool of management, organization may be misused.

The fact is that organization may be employed successfully to build a highly centralized, autocratic, and rigid enterprise; and that it may be used with equal success by the progressive leader in industry to promote decentralized, efficient, and flexible management, utilizing to the fullest the capabilities of all its members. It is the philosophy that makes the difference.

The following outlines briefly what I consider to be major trends in organization today.

THE CHANGING CONCEPT OF "ORGANIZATION"

Perhaps the first and fundamental trend is the change in the concept itself. Originally, "organization" merely meant subdividing the total job into individual tasks, and relating these tasks structurally, such that they may function as an integrated whole. This structure is established by the process of successive delegation of responsibility.

The modern concept of organization takes into account far more than these purely mechanistic, structural aspects. Management has learned that our primary concern must not be with an abstract "structure," but with the people who occupy its positions. The emphasis is therefore shifting from drawing charts to studying people. We have learned a great deal about the "informal" structures, which are superimposed on the "formal," officially prescribed organization; they are vital in getting work done. We have come to look upon an organization as a very intricate and highly interwoven fabric of relationships, and we don't delude ourselves into believing that well-defined "lines of authority" alone will do the trick of making it work. In spite of this recognition of complexity (or perhaps because of it), we have made considerable strides in gaining an understanding of the dynamics underlying organizational structures.

SYSTEMATIC ORGANIZATION PLANNING

It seems hardly necessary to elaborate on the current drive to develop executive talent; the "great American Manhunt" as someone has called it so dramatically. The literature abounds with reports on what is being done to assure continuous and capable succession to the managements of today.

It appears only natural that, wherever Executive Development has emerged on a formal basis, Organization Planning has become an integral part of it. After all, one can't do an effective planning job for developing executive manpower with a vaguely defined structure, nor without an estimate of what the organization will look like five or ten years hence.

Programs of Management Development usually consist of four elements:

1. Taking an inventory of executive manpower. This involves a listing of individuals presently in executive positions, and an appraisal of the assets and liabilities, as well as of the potentialities of this executive workforce.
2. Formalizing the organization structure. This involves an analysis of the formal relationships within the company and of the contents of executive jobs. An organization manual is the usual product of this activity.
3. Forecasting future organizational requirements. This is tied closely to market and other forecasting and involves some definite planning for the future life of the enterprise.
4. Finally, there is the development of executives to fill present and potential openings. This activity must be programmed to reconcile the current inventory with future demands. It may include all sorts of training devices (from conferences to job rotation), as well as a continuous process of rating and counseling.

EXECUTIVE POSITION DESCRIPTIONS

Related to organization planning is the trend toward the writing of executive position descriptions; the analysis, definition, and evaluation of executive jobs. Being an outgrowth of the well-known "functional statements" of organization charts, these position descriptions serve as a basis for performance standards which must underlie, necessarily, the rating of executives. The art here is to write these statements in a fashion which will not stifle the executive, but facilitate his growth.

THE INCREASING SPAN OF CONTROL

According to Graicunas' classical principle, the number of people reporting to an executive must be limited, since the difficulty of supervision increases exponentially with this number. (Difficulty of supervision is measured here in terms of the interrelationships involved). This number, which is referred to as "span of control," is usually recommended to be between three (for top management) and about six or seven (for middle management). The foreman, managing routine operations, may supervise a much larger group, of course. With the increasing attention given to the development and the productivity of executives, it became apparent, however, that short spans of control may have distinct disadvantages.

It is evident, for instance, that a short span allows more time per person supervised, and therefore encourages "oversupervision"; this, in turn, fails to stimulate delegation of responsibility, and results in a decision-making bottleneck at the supervising position, and in poor morale, poor productivity, and poor utilization of the capabilities of subordinates.

A second disadvantage arises from the fact that, for a given number of people, short spans of control necessarily mean long chains of command ("steep" structures). As a result, people on the bottom of the hierarchy tend to become isolated, by numerous levels of supervision, from the leadership on top. These many intervening levels tend to obstruct two-way communication, and lead to rigidity of administrative practices.

With this in mind, companies such as Sears and Roebuck have been changing over, deliberately, to wide spans of control ("flat" structures). This is based on the assumption that this practice will result in better bottom-to-top contacts, will prevent executives from over-supervising, will force delegation, and will thereby tend to develop subordinates to their maximum capacity. The key point here is that span of control is largely a function of the extent of delegation. The more one delegates, the wider a span can one afford. Dr. Pfiffner refers to delegation characteristically as the "third dimension" of organization.

DECENTRALIZATION

This whole question of increasing productivity by developing individuals to the point where they can contribute to the fullest possible extent, is of fundamental import. It is based on the assumption, borne out by recent research, that a man will do a better job, if he is given all possible responsibility to run his own show; if he can put his own initiative to work; and if he feels that he has a real stake in the results of his efforts. This philosophy has led to a general movement toward decentralization. This does not necessarily mean geographical dispersion, but rather the pushing down of the "locus of decision-making" to self-contained units at the lowest practical level of the organization. This is important in the large, as well as in the small enterprise.

The Small Business in Transition

In the small enterprise, strongly centralized decision-making is very typical; particularly, in the company which the owner-manager has built up "with his own hands." As the organization grows

until it employs about 100 or more people, paralysis begins to set in. The top man no longer has sufficient time to do everything. But how could he delegate what he knows so much better than anybody else, having made all important decisions for 10 or 15 years? At this point, it becomes essential to develop subordinates and let them make the decisions pertaining to their functions.

Some small businesses are beginning to realize that one of their most serious problems of transition is organizational in nature. This realization comes only slowly, however. More often than not, problems of organization are diagnosed at this stage as problems of "human nature," interpersonal friction, inadequacy of subordinates, and the fact that our business is "different." The skill and the insight necessary for successful delegation are yet to be mastered by many executives.

The Large Corporation

This structural problem is similar in the large corporation. The overwhelming trend is away from centralized decision-making, with plant managers merely acting to relay orders from the home office. Today's multi-plant organizations stress autonomous, self-sustaining plants. The home office provides only over-all policy and specialized consultation. The plants are charged for these services on a prorated basis, and individual plant managers are held accountable strictly on a profit-and-loss basis. Examples of this type of decentralization may be found at General Electric, DuPont, Sylvania, and many others.

LINE AND STAFF

The line-and-staff relationship is undergoing an important change, too. In the past, there prevailed a tendency to strip the line organization of authority in various specialized areas, and to vest this authority in functional staff groups. Outstanding among these were Personnel departments, Planning and Control departments, and others. This trend has been reversed, but without sacrificing the usefulness of these staff groups. The increasing complexity and specialization of management certainly make staff work tremendously useful—indeed, indispensable. The emphasis today, however, is squarely on the line executive, particularly the first-line supervisor, as the key to a sound and productive organization. Staffs are organized to strengthen his position, and their "institutionalization" is guarded against.

"Assistant To" positions, a special case among staffs, have been recommended widely. L. Urwick, one of their principal proponents, urges the use of "Chiefs of Staff" as a means to extend the executive's capacity and to train future executives, particularly "generalists," with an over-all background.

RESEARCH IN ORGANIZATION

A discussion of current trends would not be complete without some reference to various research being carried on in this field. In most cases, this research has come into being through the impact of the social sciences on management thinking. While the results of this research, to date, have not been spectacular in terms of establishing specific "laws" of organizational behavior, they have afforded us a great deal of insight into the dynamics of our industrial institutions. Consequently, many industrial and management engineers have been quick to recognize the merits of this approach and the promise it gives for supplying more specific answers in the future.

Structure and Communication

An interesting engineering approach to questions of organization has been taken at the Massachusetts Institute of Technology, although on an admittedly oversimplified basis. Dr. Bavelas and his disciples conducted large numbers of experiments with small groups of people. These groups were arranged in various organizational patterns, allowed to communicate only by means of written messages, and instructed to solve different standardized card problems. Based on such criteria as time required for the problem solution, number of errors committed in the process, maintenance of personal interest on part of the group members, etc., various relationships between organization structure and problem-solving efficiency were established. While the researchers themselves are the last ones to make any claims as to the significance or general applicability of the outcome, their approach comes to grips, at least, with organization in quantitative terms.

Sociometry

Another way which promises a quantitative approach to organization has been found through the application of Sociometry. This field of study has been pioneered by J. Moreno. It attempts to measure relationships within a group, based on various aspects and degrees of interaction. Suffice it to say that a quantitative picture and some real insight into the dynamics of industrial groups can be gained in this fashion. The results of such an analysis can be portrayed graphically by plotting "sociometric scores," constructing "sociograms," and other means. In some cases, productivity has been increased considerably by organizing work groups along lines of maximum compatibility, based on these sociometric scores.

Other research is attacking organizational problems in terms of such variables as "leadership climate," "intergroup tensions," "decision-making," "communication," and many others.

SUMMARY

Summarizing this discussion, we find "organization," originally a purely mechanistic concept, transformed into a dynamic, human management tool. This approach has underlined how many of our industrial difficulties are really organizational in nature; it keeps reminding us that, in the final analysis, it's the people that count!

We have seen trends

- to shift the emphasis from "structure" to people,
- to "formalize" organization planning and to tie it in with Executive Development,
- to analyze, define, and evaluate executive positions,
- to increase the span of control and to lower the "locus of decision-making,"
- to decentralize and thereby develop self-reliant executives,
- to utilize staffs to the fullest, but to put the burden on the line organization.

Finally, we discussed some research which promises eventually to supply answers to some of our questions on organization.

Most businesses, however, have as yet to take advantage of what we know about organization today. Some of the principles of organization are quite old, but their application is rare. The field is wide open for the industrial and management engineer.

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Book Review

"Principles of Automatic Controls,"
by Floyd E. Nixon,
Prentice-Hall, Inc.,
New York, 1953, 409 pages, $9.35

The design of servomechanisms and automatic controls is the subject of this volume by Mr. Nixon. Although the author discusses and explains the advanced mathematics required, the average engineer will need more than the usual calculus background to follow this (or any other) book on servomechanisms. Mr. Nixon has done an excellent job and has included an extensive appendix of reference material.

Professional Responsibility and the AIIE

By Donald B. Wilcox

Professor of Industrial Engineering, University of Florida

Based on an address to the Jacksonville Chapter, AIIE, Organizational Meeting, March 9, 1953

First off, perhaps we should define what is meant by a profession. Dean Marston of Iowa State College has defined a profession as: "A calling which is pursued only by an organized body of men possessed of high scientific qualifications for special work by reason of thorough educational training and extensive responsible experience, and from whose ranks the unfit and unworthy are rigidly excluded." Let us look for a moment at the individual characteristics of professional practitioners. One of the first that we note is that of education. I am tempted here to digress and discuss just what that education should embrace but will leave it in hopes that at subsequent meetings of this organization perhaps you can contribute some excellent suggestions along that line. Another characteristic of the professional practitioner is that of experience; the physician must first serve as an intern in a big city hospital, the engineer gains his experience on drafting boards and in shop work in industry. Finally, a truly respected professional man is known as a member of civic and professional organizations.

Then there are the group characteristics of a profession. One of the outstanding characteristics is that of recognition and respect. When a man is introduced as a lawyer, or a doctor, or a teacher, he is at once recognized as being a professional man, by virtue of his duties and the high esteem in which these callings are held by the public. Another distinguishing characteristic of professional groups is that of their rigid regulation and the high standards which must be met prior to admission. The state undertakes to regulate many of the professions by the issuance of licenses to practice. These licenses are issued by boards of professional men, acting with authority of the state, only upon satisfactory proof of the individuals' qualifications. A final group characteristic of all professions is the nature of their obligations: First of all, to the community. Every profession renders service to the community at large and to the individuals which compose it. The second obligation is to the profession itself, as demanded by the canons of ethics, promulgated by the group and subscribed to by every member. Finally, a professional man has an obligation to himself as evidenced in both his own moral code and his continuing efforts to improve himself.

We are all familiar with the trend towards specialization in the various professions. In medicine, in our own lifetime, many of us have seen the progress from the old fashioned midwife to the modern obstetrician, pediatrician, and more recently the gerontologist; so that from the cradle to the grave, we pass from one specialist to another. Perhaps the very latest word in medical specialization is the field of the diagnostician. He is the man who collects a fee for telling us **what kind** of a doctor we should consult next. Turning to the field of law, we have come from the old style general counselor to the modern labor-law attorney, tax lawyer, and divorce specialists. Most of you, I am sure, recognize that engineering was originally a military profession. The first of the various branches of modern day engineering was that of Civil Engineering as represented by the break away from the military applications of engineering devices and techniques. Then came Mechanical, Electrical, and with increasing rapidity, Chemical, Textile, Petroleum, Mining, Industrial, and a host of other divisions of engineering.

To discuss the various branches of engineering is somewhat analogous to the discussion of denominationalism in church work. Just as various churches have minor differences in their creeds and procedure but conform in basic philosophy, so do all the branches of engineering subscribe to a general program of basic academic discipline.

The field of Industrial Engineering probably would not exist today if the Mechanical Engineering profession had not been so terribly absorbed in machine design and power generation problems, that production problems, costs and the tremendously important, yea the **paramount** factors of human consideration were neglected.

Actually, the field of Industrial Engineering had its origin about 1906 when Purdue University offered the first course on record of what was then known as Human Engineering. A few years later, in 1912, the first full curriculum leading to a degree in Industrial Engineering was offered by my own college of Penn State. Gradually other schools adopted the new type curriculum, and with the impetus given the movement through the accomplishments of Industrial Engineers during the recent World War II, we have seen a great expansion of Industrial Engineering education since 1945. There appears to be an almost insatiable demand on the part of industry today for men well grounded in basic mathematics and fundamental science who have had, in addition to that work, training in management philosophy. There have also been developed a number of highly specialized fields within the field of Industrial Engineering such as production control, materials handling, quality control, factory layout and design, industrial relations, patent work and transportation. I have participated in countless discussions attempting to pin down a suitable definition for industrial engineering. Such semantic exercises are generally more time consuming than they are productive. The best identification I have been able to establish in my own thinking is not so much a definition as it is a demarcation. As I have already intimated, the Industrial Engineer is distinguished from all other types of engineer by his interest in Dollars and People. He is essentially a coordinator, a compromiser if you will, who seeks to maintain that critical balance of perfection, profits and people which is the secret of the success of American industry today. Some may say that such an individual is invading the field of the Business Administration graduate. Here again, I believe we will find a rather clear boundary. The management graduate is concerned with marketing, sales, finance and similar fields of activity dealing with customers up to the time they place their orders. Then it is the Industrial Engineer who takes over and determines how the ordered items shall be produced, when, where and by what methods, so as to produce the required amount at the required time with proper quality and at such costs as to provide equitable rewards to all parties concerned.

But let us return to the subject of our responsibility for a moment. Being a professor, I cannot refrain from again resorting to a tabulation. I think it is interesting to compare the various professions from the standpoint of their objectives.

Looking first at the doctor, we note that his function is primarily that of remedying trouble, of restoring health. Turn now to the legal fraternity, and here if you will permit me, I will speak as a member of that profession and in defense of it for a moment. I would point out that rather than merely exist as parasites, living on the exploitation of the misfortunes of others, lawyers actually seek to assist people in **avoiding** trouble and in drawing up legal documents which will facilitate commerce and industry. Now, laying aside legal robes and symbolically picking up an engineering slide rule, I feel that we can well boast that the primary objective of the engineering profession is to **improve** the existing status of things. The engineer always is on the alert for new and better ways as the duPont company slogan so well expresses it, "New and

Better Ways for Better Living." I was particularly impressed by an anecdote which Mr. Bernard Baruch relates. When he earned his first million dollars, he rushed up town in New York City to his father's office to report the good news to him and was quite taken aback when instead of being congratulated by his father, he was asked the challenging question. "What are you going to do with it?" So, too, does education give rise to responsibility. And so does leadership. The professional engineers of this country, 400,000 of them, comprise only three-tenths of one per cent of the population and yet the future welfare, indeed the future security of this nation rests on their shoulders. It is difficult to isolate our separate responsibilities and it is also difficult to isolate organizational demands from our responsibilities. The Boy Scouts subscribe to an oath to serve God, country and others and in serving any one they cannot help, in most cases, but serve the other two. So it is with the professional responsibility of mature men. What are the hallmarks of a professional man? First, we have that of purpose—other than that of making money. A professional man has a driving purpose which we generally call the desire to serve. He also has a philosophy, or a breadth of interest considerably wider than his own limited sphere of work. He has a dignity, a pride, a prestige. He has a personal responsibility for his work and he has a code of ethics. I think one of the best, most terse and yet most complete definitions of ethics that I have run across is that of Dr. Elton Trueblood when he called it "The science of right conduct."

Now to crystalize some of this professional responsibility of which I have been speaking, I would like to be able to get across to you what organizations such as the AIIE can do for you, and what you in turn owe to your profession and to such organizations as the American Institute of Industrial Engineers. But before becoming specific as to organizations, it may be interesting to turn our attention for a moment to the large number of possibilities which exist. If you will consult the World's Almanac, you will find some seventeen pages of two columns each listing all manner of organizations which we have here in America. They run the gamut from the Association for the Perpetuation of Circus Parades to such staid organizations as the American Philosophical Society; from such bizarre organizations as the Tall Club to the Anti-Profanity League. In engineering alone we have many organizations: The National Society of Professional Engineers is, as the name implies, a professional organization which undertakes to look after the economic and sociological implications of the engineering profession. Then we have many technical organizations of which this is one. Each of the founder societies, the American Society of Mechanical Engineers, Civil Engineers, Chemical Engineers, Electrical, etc., has its own organization which undertakes to promote a continuing program of technical information and education for its members. In the field of Industrial Engineering we find, in addition to the AIIE, the Society for the Advancement of Management, the American Management Association, and a very strong management division in the American Society of Mechanical Engineers. The American Institute of Industrial Engineers is a relatively young group as it was formed as recently as January, 1948. However, it is already well established and holds promise of being the outstanding organization for practicing professional Industrial Engineers.

Now, I well recognize that we all have tremendous pressure on us to join these various organizations. There simply are not enough nights in the week to attend the many meetings which we are being constantly urged to attend. Religious organizations, civic clubs, social organizations, alumni group meetings and trade assocations vie with one another for our evenings out. However, I sincerely feel that the technical organization of one's own branch of the profession offers so much that we can ill afford to miss the rich rewards to be gained by maintaining membership and attendance. Actually, participation in organizations of all types is stimulating and helpful in developing our abilities. It is a platitude, I know, but nevertheless true that what one gets out of an organization, is in proportion to what one puts into the organization. The American Institute of Industrial Engineers is organized with its greatest strength at the local chapter level. Meetings are held at the pleasure of the group which is, normally, about once a month. These meetings afford opportunities for very interesting and helpful professional contacts. Sessions are devoted to technical subjects which many of you will find most helpful in your work. Another activity of organizations such as this one is that of arranging plant visitations so that the various members can visit each others' plants for conducted group tours. It has been the experience of many that out of such tours come helpful ideas and suggestions for improving their own work. For those of you who are interested in committee work there is a great deal of worthwhile constructive effort still needed to properly organize the subject matter of Industrial Engineering. If you are interested in technical expression, writing of articles for the national Journal or even the reading of the articles which are presented in that fine magazine is another advantage of membership in this organization. Social contacts, an opportunity to develop your own professional leadership, information about job opportunities, salary and promotion data and a program of professional and vocational guidance for young men are other objectives of the American Institute of Industrial Engineers.

Book Review

AUTOMATION

By John Diebold

D. Van Nostrand Company, Inc., New York, 1952. 181 pages. $3.00.

An extremely well-done treatment of great interest to all future-minded Industrial Engineers. Mr. Diebold has stated in simple terms the importance of Automation as a logical extension of mechanization. A brief treatment of the importance of control and communication theory, computer functions (both analogue and digital), product and process re-design, and the mechanical problems involved in Automation are supplemented by presentations on the social and economic importance of Automation. The further development of Automation is seen by the author as a possible solution to many of our most pressing social and economic difficulties. The book is very likely to cause the reader to do serious thinking about present and future applicatons of Automation relative to his own work.

SATISFACTIONS IN THE WHITE-COLLAR JOB

By Nancy C. Morse

Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, 1953. 235 pages. $3.50.

This book is one of a series reporting research activities of the Human Relations Program of the Survey Research Center of the Institute for Social Research. The previous volumes reported on studies of supervision, morale and productivity in an insurance company, and in a railway company. These works, along with studies by other researchers, have highlighted the importance of nonmonetary factors as determinates of productivity and job satisfaction. The present volume will be of interest to all concerned with supervision and employee relations, particularly those engaged in office activities.

OFFICE MANAGEMENT AND CONTROL

Revised Edition, by George R. Terry

Richard D. Irwin, Inc., Homewood, Illinois, 1953. 763 pages. $8.00.

Because of the increasing proportion of total cost going to clerical functions, application of industrial engineering principles to office work should be and is getting increasing attention. Prof. Terry has written a very useful and comprehensive book on all important phases and functions of office management. He shows the usefulness of industrial engineering methods in clerical work.

The author includes a brief history of office work and a general discussion of organization and management. He discusses facilities, equipment and personnel relations. He describes the latest and best methods of performing office functions such as reporting correspondence, and filing. He emphasizes managerial control, standards, procedures, and work simplification.

The Achilles Heel of Industrial Engineering

By D. H. Denholm
Chief Industrial Engineer, Chase Bag Co.

Why do most scholastic procedures take the joy, interest and romance out of the subject studied. In reducing the subject to its basic quantities, academicians too frequently reduce the live, vital and fascinating item to a series of sterile formulae.

When the engineering school diverts from straight mathematical concepts, this is especially so. "Technique" and/or "Concepts" demand 46 to 48 semester hours—Human Relations, two.

One of the worst offenders is found in Industrial Engineering or Industrial Management (or other closely allied names). The young student is turned out armed with a limited working technique (complete with statistical procedures to "Prove" his every step). A great deal of time is spent in elaborating on long, involved and minutely detailed procedures.

The Professors acknowledge weak points of their concepts with a dry smile —devote a small portion of the class session to it and move on to more fertile fields where they can expostulate, demonstrate and prove their every move.

Motion and Time Study is especially vulnerable in this critique.

Bright eyed graduates approach their work with smoking slide rules. Watches click, MTM charts are brought out, methods standardized or synthesized, movies taken, simo charts made (maybe), statistical P bar and double bar calculated. The final standard then announced with fanfare as factual, fair and pure—a sparkling example of virginal accuracy (within 2 sigma limits or perhaps three, of course).

Up to this point I have no quarrel with the educators, but from here on in they do an inadequate job.

In many respects their work is analogous to the man who decided he wanted to be a trainer of lions. He studied every book on the subject he could lay his hands on. He attended every circus that came to town. He traveled to neighborhood cities to visit their libraries and their local zoos. After 25 years of this intense concentration, he felt that he had mastered the absolute knowledge of lion's habitat, its actions and its feelings. He decided now was the time for him to move forward in his profession. Approaching the next circus that came to town, he announced the fact that he was a master at training lions—he would be delighted to lend them his council. It just so happened that the circus had purchased a lion which was not performing according to expectations. It refused to be trained. The eager, but neophyte trainer, expressed the thought that every concept of this was made to his order. Would they please release the lion into the training pit with him. At the appointed moment our neophyte, armed with his chair, bull whip and gun (full of blank cartridges) gave the sign, and the lion entered the arena. One minute later the lion had killed our hero.

The moral of this tale, of course, is our friend had read and understood thoroughly all aspects of how to control lions —but the lion had not.

I don't believe that the educators themselves (and this applies to the writer also) are aware of the fact that they present the easiest part of the job. One that any I.Q. of 120 could present. Maybe we can even lower the professorial I.Q. to 90, when we realize that the subject matter is repeated year after year.

We do not give the student enough of the far more difficult part of the job—the practical application of his techniques.

One educator took me to task when he indicated that they are placing adequate tools in the hands of the young novice. The tools are complete. Instructions in the use of the tools are detailed—what more can he do?

Just showing the young mechanic how to use an open end wrench and where a box wrench is used and why a socket wrench is used—is so basic and primary that it is hardly worth recognition beyond grammar school level. Certainly not deserving of college consideration.

What happens to the young mechanic when his wrench won't reach the nut or when the nut is frozen to the bolt, or when the nut shears off the restraining bolt, or when the nut is of a bastard size, etc., etc.

What we are saying, of course, is that the ultimate we expect of the educators is to deliver to us a fully experienced man. We agree that this cannot be done, but we can do much better.

We believe that constructive criticism should always be accompanied by suggestions and so we offer the following. We are quite sure that it deserves a great deal more development, but we hope it will stimulate some of those in charge of our Industrial Engineering curriculum in our colleges to do some thinking.

Suppose we divide each of our practicing courses (like motion and time study) into two parts—Part A. consisting of the concepts, Part B. consisting of case histories. I believe concepts including the typical operation process charts, the typical analysis that goes with them, the modern up to date statistical procedures, motion and time study techniques, all tools—are reasonably well covered now and should be presented in this session.

Our thought is that Part B should follow each announced concept with actual **case histories**—preferably those where straight concept approaches **failed.** These case histories to be detailed and above all—an honest record of an actual story.

The professors have the tools to collect this information even if they do not have the opportunity to experience them personally. Their own students, once graduated, can report back to them. Graduate students can be assigned the task of collecting them. The professors themselves can make it a point to ask permission to sit in on industry, problems and disputes, concerning methods and standards.

To further illustrate is difficult because our own approach to this may not necessarily be the answer.

As a typical example let us submit this. We have just concluded session A, where the concepts regarding the establishment of a standard have been thoroughly and firmly practiced and understood. Let's further assume that the instructor is alert and sponsors a lively class discussion on each of the questions following this next story.

YOU CAN'T FIGHT CITY HALL

For years management and the union had been bickering over the piecework rates set on individual operations. In an effort to keep production rolling and because of a series of management changes, concessions were continually made to the union. The result of the long time concessions was that only the "more attractive" piecework rates were being used. The controversial items were being produced at a carefully controlled rate of production. The pay for these items was the operator's average hourly earnings for the highest of the four previous quarters.

The items were all hand produced by the individuals working with a machine. The machine was operator controlled.

The pressing matter of costs brought management's attention to this department. Production in other branches of this same company indicated that production and costs could be drastically lowered.

Industrial engineering was called in to help work out this problem (actually 15 disputed rates). The controversial items were carefully scheduled through the departments and time studies were taken on groups of the girls. Each group was chosen by the superintendent and the union steward. During the course of the study the union steward was time studied. She put on an amazing demonstration of speed, disposing of the

work at double the usual pace. In explanation she said, "I didn't want you to accuse me of holding back. Of course, I couldn't keep this up—besides the material was very good." The three other girls involved were having a seemingly difficult time. Their production was far below the normal slow rate.

During the course of these studies a second union steward accompanied the time study man. She was asked to take her turn. As with the other girls there was extreme difficulty in producing.

Since these items were constructed of a base material which sometimes varied (cloth glued to paper with asphalt), the operators found this a handy whipping boy for all their troubles.

One operator had an especially difficult time. Fumbles and drops were frequent. They continued in spite of repeated requests by the time study man to use the proper methods and to cooperate more fully. Finally the study had to be abandoned because of the extreme variability of the elemental times. The steward was told that the obvious non-cooperation was making it difficult for the time study man to favor—if such a thing is possible—the operators. Either the request or the too obvious malingering had an effect.

The following day the steward approached the T.S. man and explained, "I talked to Mary last night. She said that she was so nervous that she just couldn't act natural. Try her today, I think you will find her all right."

The studies continued until all 15 items had been either verified or modified.

The group and their union representatives were called together and each study, its resulting rate and its effect on each person was reviewed. Charts demonstrating earning potential and allowance applications were displayed. A brief comment on the degree of accuracy through the use of statistical means was given. Most of the rates had slight changes, the remainder none. The authenticity of the studies was vouched for by the steward who assisted in the taking of them.

There was little comment by the operators. The observer got the impression that much of what was being said was either being completely accepted or was not being understood. The meeting adjourned in a friendly atmosphere. The operators asked for a closed meeting. Management representatives retired to the nearest "coke" machine to wait. Fifteen minutes later the committee informed the group that all the rates had been rejected.

The deadlock continued for six months. During contract negotiations six months later, the company managed to rewrite the clause concerning piecework installation.

The new clause was obtained by making concessions in granting additional wages. The clause stated, "Piecework rates will be installed at the company perogative for a trial period of thirty days. At the end of that time the union has the right to file a grievance or accept the rate. Grievance procedure was a four step plan, affording a review by all during each step. The final step being arbitration."

Shortly thereafter the first of the disputed items was placed in production and the contested piecework rate was made effective. A concerted effort was made by management to see that the supervision was adequate. The manager, the time study man, the I.E., the superintendent, and the foreman all converged on the department. The result of the concentration was that the operators produced at a rate exceeding their former production. Their earnings approached their former guaranteed rate. Ten of the fifteen controversial items were so processed. The remaining five left for a later date. Of the ten only one item gave difficulty because of faulty material—it was quickly agreed that this rate would be withdrawn.

At the conclusion of the trial period there were no grievances. The management group was content. The reaction was mixed, Mary said to the steward, "Sure I'm doing all right on a couple of rates but there are a couple that's not doing me any good at all—Aw—you can't fight city hall."

Questions

1. Why had top management replaced the management of this plant so often?
2. Why had these replacements not insisted on meeting these disputed rates as soon as they learned of them?
3. Should it have been necessary to force a "long" trial of these rates in order to gain acceptance?
4. Why did the group reject the suggested rates when their own steward had accompanied the T.S. man and had vouched for the readings?
5. Was the group impressed by the charts and assurance of statistical accuracy?
6. What made the operator, who fumbled, recover her composure the next day?
7. Had the operators anything to lose by rejecting the proposed rates?
8. Was there anything wrong with the IE's concepts?
9. Would another manner of paying for the time spent on work covered by the contested rates help?—What would this be and how would the workers accept it?
10. How could this expensive controversy have been prevented?
11. Why did the approach used "work"?

That's the pitch, professors! You have the ball now. Can you improve on the overall quality of the Industrial Engineering graduate you deliver to us?

Book Review

RESEARCH OPERATIONS IN INDUSTRY

Edited by David B. Hertz and Albert H. Rubenstein

King's Crown Press, Columbia University, New York, 1953. 453 pages. $8.50.

Included in this volume are all of the papers (and edited discussions of the presentations) presented at the Third Annual Conference on Industrial Research held at Columbia University in June, 1952, plus selected papers from the previous conferences. The main sections are titled Philosophy and Management's Appraisal of Research; Economics, Costs, and Budgeting; Personnel in Industrial Research; The Planning of Research Programs; The Planning of Research Facilities; Research Methodology and Design of Experiment; Operations Research; and Communications and Technical Information Services. The coverage achieved by skillful selection and editing of the presentations from the three conferences will be appreciated by individuals engaged in research activities of all types.

ENGINEERING STATISTICS AND QUALITY CONTROL

By Irving W. Burr

McGraw-Hill Book Company, Inc., New York, 1953. 442 pages. $7.00.

Prof. Burr has approached the field of statistical quality control from the underlying mathematical theory. Therefore, his book fits well into the current trend toward the use of more advanced mathematical techniques in quality control and industrial engineering. Although the mathematical level is advanced, there are many examples and discussions to relate the theory to industrial practice.

Prof. Burr, in starting with the basic statistical measures, places emphasis upon frequency distributions, the normal curve and probability theory. He has a thorough discussion of control charts for attributes and for variables. In addition, he includes good coverage of the methods and practices of sampling inspection plans both for attributes and variables.

TIMESTUDY TRAINING AIDS

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Consistency in Speed Rating

By R. G. Carson, Jr.
Associate Professor, Textile Management Department, Clemson College, Clemson, S. C.

Rating is an important part of the everyday time study procedure used by most industrial plants. It is thought by some to be one of the weak links in the usual method of determining the proper work load. A good many tests have been made and experiments run to determine how accurately rating can be done. Results have not been uniform. A summary of the results of some of these tests follows:

1. Louden reports on some studies made in industry without giving much detail. He indicated that five percent of the ratings made were more than fifteen percent from the group average. The studies point out that increased accuracy in rate setting can be obtained by using the averaged results of several time study men.
2. Carroll used motion picture films to train two groups of observers in rating. He used sixty as the base or normal position on the rating scale. After ninety sessions, the group of twelve had 85 to 90 percent of its ratings within plus or minus 5 points. Another group of 122 men, after fifty such sessions, had 75 to 80 percent of its ratings within plus or minus 5 points.
3. Schell reports an interesting study, but some of the details are lacking. Seven hundred and fifty industrial trainees and university students were given the same training program. After a few months in the shop they were called back and their ratings checked by test. Thirteen of the observers were out as much as 38 percent and Schell notes that almost any observer is likely to be out as much as 15 percent on any one estimate. Sixty-three experienced observers were used in another test. Eighty-nine percent of their estimates were within plus or minus 15 percent; 67 percent of their estimates were within plus or minus 10 percent. Again, the fact that the average of ratings by different men is more accurate than any single rating is noted.
4. Barnes studied, at a series of conferences, the piece rates and ratings of a group of time study men from different plants of the same company. After the seventh conference, the observers showed a consistency of from plus 3 to minus 7 percent in their ratings. Barnes also notes the results of Eli Lilly and Company who reduced the mean deviation of rating walking and card dealing to 2.4 by a series of weekly training sessions. Systematic error was also reduced to minus 2.3 for walking and plus 0.8 percent for card dealing.
5. Mundel and Keim had a group of approximately fifty trained time study engineers rate films of 57 performances at different paces. Forty-six percent of their ratings had less than 10 percent error.
6. Mundel noted that the study of Lehrer, involving 31 trained time study engineers, who rated films of a laboratory job, showed 19 percent of the ratings within plus or minus 5 percent, and 42 percent of the ratings within plus or minus 10 percent. This is substantially the same result as the study of Keim.
7. Ela and Lockett analyzed the ratings of 75 observers from different companies. The men rated films of actual factory operations and of laboratory jobs. In both cases, 38 percent of the ratings were within plus or minus 5 percent and between 86 and 90 percent of the ratings were within plus or minus 20 percent.
8. Walters conducted a series of experimental ratings sessions involving more than 70,000 individual ratings and 135 men. The average absolute error for the group was slightly more than 5 percent. For those performances close to normal, the average absolute error was 4 percent.

The information contained in the above studies is summarized in Table 1. There is a wide variation in results. This is due in part to the variations in the procedures used. Some investigators used experienced time study men only, others used inexperienced personnel. In most cases films of operations were employed, but in some cases actual factory or laboratory operations were used. In a few cases, the training of the personnel was such that they should have rated alike; in other cases the men used as observers came from different companies, using different concepts of normal or different methods of rating.

In addition to the experiments cited above, some authors have made unsupported statements about how well rating can be done. These range from that of the CIO-UAW that rating is a purely subjective estimate, which may or may not be better than the guess of an experienced worker, to that of Schutt who stated that there would not be a difference of two percent between two ratings on operators performing the same job. No attempt is made to do more than mention that such assertions exist, and in some cases have been given all too much weight, simply because they came from the printed page.

This study is concerned with how well a group of men who had all been trained alike and knew the operations, could rate. It compares the level of the rating of each man to that of the other men in

TABLE 1
SUMMARY OF RATING INVESTIGATIONS

AUTHOR	EXPERIMENT	RESULTS
Louden	Study by an individual company	95% within 15% of the group average
Carroll	12 men all trained alike, in 50 film sessions	85 to 90% of the ratings within 5 points (8.3%)
	122 men all trained alike, in 50 film sessions	75 to 80% of the ratings within 5 points (8.3%)
Schell	750 previously untrained men, all trained alike	13 observers out more than 38%
	63 experienced observers	67% of the ratings with 10% 89% within 15%
Barnes	Men from different plants of the same company	Range of error: from plus 3% to minus 7%
	Eli Lilly, walking and card-dealing	Mean deviation 2.4% on each
Mundel and Keim	50 men rating 57 films	46% of ratings within 10%
Lehrer	31 trained time study men from different plants	19% of ratings within 5% 42% of ratings within 10%
Ela	72 engineers attending conference, rating films of factory operations	38% of ratings within 5% 90% of ratings within 20%
Lockett	72 engineers attending conference, rating a laboratory job	38% of ratings within 5% 86% of ratings within 20%
Walters	125 supervisors, 10 time study men, all trained alike	Average absolute error slightly more than 5%

the department. It also compares the level of the rating made at one time to the level of the rating made on the same operation by the same man at another time. The study does not attempt to say that the level of the rating (rate of performance expressed by a speed rating) is right or wrong. It is the belief of the author that the ratings made within a plant should be consistent with each other. That is, that all men in the department have the same conception of normal, and give performance about the same rating. It is not so important that the concept of normal be exactly the same as that used in other plants, even near-by plants, though this might be desirable. Films like those put out by the S.A.M. are designed to achieve this sameness, if not of "normal," then of "expected production," per period of time.

The company whose data is used here performs punch press, welding, staking, assembly, some machining, inspection and packing operations. The company uses time study to set rates for wage incentives purposes. Part of the procedure used was as follows:

The company made a motion picture of almost every job time studied. The picture was taken with a constant speed camera at the rate of 1000 frames per minute. When the film had been developed it was made into loops and filed. Loops were rated by all the time study men during weekly rating sessions. If a film loop was good from the technical point of view and the operator was reasonably consistent, it was marked "Record" and then used in future rating sessions. Some loops have been rated as many as ten times over a period of twelve years. The films were rated at four projector speeds, one of which was 1000 frames per minute. A tachometer equipped projector was used for this purpose. A departmental secretary ran the projector, and only she knew the projector speed during the time the loop was being rated. Ratings by all men were recorded on a single form after the film loop had been shown at the four speeds. The ratings for those speeds other than 1000 frames per minute were brought back to a 1000 frames per minute basis by ratio and proportion, and both the actual ratings and the corrected ratings were posted. Completed forms were filed.

For the purposes of this analysis, only those ratings made at a projection speed of 1000 frames per minute are used. The study was limited to the six men who appeared in the records most often. Sixty-three film loops were used in the analysis. The period covered by the rating sessions used is primarily from September, 1945 to September, 1951.

Table 2 shows the number of loops, number of sessions and number ratings made by each man. The average of all ratings ever made on the film loop is used as the correct rating and, of course, includes some ratings made by the men under analysis. No other criterion was available by which the film loop could be measured. In every case except one this average or "correct" rating included more than 100 individual ratings made by at least 7 different trained time study men.

TABLE 2

NUMBER OF FILM LOOPS RATED BY EACH MAN DIVIDED ACCORDING TO THE NUMBER OF TIMES (RATING SESSIONS) THE LOOP WAS RATED

Man	No. of Sessions the Loops Were Rated							Total No. of Loops	Total No. of Rating
	2	3	4	5	6	7	8		
A	1	11	19	15	9	3		58	261
B	4	5	24	16	8	2		59	261
C	2	7	27	11	4	2	1	54	234
D		6	21	11	3	4		45	203
E	1	2	10	5		1		19	80
F	1	7	19	9	3	1		40	169

Method of Analysis:

1. All ratings were converted to a percentage of the correct rating. This was done by the formula:
$$\frac{\text{actual rating}}{\text{correct rating}} \times 100$$
This converted figure was used thereafter. The purpose of the conversion was to make comparable an individual's ratings, regardless of the level of production rated. For example, the rating of a relatively slow performance might be converted to 102% of the correct rating. The converted rating of a fast performance might also be 102% of the correct rating.
2. The converted ratings for each loop were posted to an analysis sheet. One analysis sheet contained all of the ratings made by one man.
3. An analysis of variance was run on the ratings made of each loop. The within column variance is the time study man's variance and the between column variance is the difference between men. The one percent level of significance was used in testing for difference in means.
4. An analysis of variance was computed of the ratings made by each man. Each man's totals for each loop was transcribed from the sheets used in step three to a separate sheet. This sheet then showed the results of this man's ratings of all loops. Each loop was in a separate column and the within column variance now shows the variability of the man for any given loop; the between column variance shows the difference in his ratings between loops. Again, the one percent level of significance was used in the test.
5. A Bartlett's test for homogeneity of variances was made on the data of step four. This tests whether the variances on the different loops could have come from the same universe of variances; that is, whether there are any significant differences between the variances for the different loops.
6. The totals for all film loops for each man were studied by the analysis of variance technique. The figures for each man were in a separate column and the between column variance became the difference between men. The one percent level of significance was used as the test for difference between means. The standard deviations for each man and for all men together were also computed.
7. A test for homogeneity of variance was made, using the total of all loops for each man. This tested the total variance of each man against that of the other men for significant differences.
8. The average percent error of the ratings of each man, and of the ratings of all men together, were calculated.
9. The number and percent of ratings within plus or minus 5%, 7.5%, 10%, and 20% were determined for each man.

RESULTS

The analysis of variance of the ratings made on each loop showed that in only one case out of 63 was there a difference between men in their ratings. This can hardly be considered significant, since one loop out of a hundred would show a difference due to chance alone at this level of significance.

Table 3 gives the results of the other tests. An explanation of the table follows. The paragraphs are numbered like the rows in the table.

1. The number of ratings is the total number of ratings for all loops used in the analysis.
2. The average rating is the average of all the ratings after each has been converted to a percent of the correct rating. One hundred represents the correct rating based on the composite judgment of all the time study men who rated the loop. In every case, the difference between the average rating and one hundred is very small, and in no case is the difference statistically significant.
3. The average percent error is the amount on the average the rating differed from the correct rating.
4. The standard deviation is a statistical measure of spread in the ratings. If the distribution of ratings

TABLE 3
CALCULATED VALUES AND LEVELS OF SIGNIFICANCE OF INDIVIDUAL MEN AND TOTAL OF ALL MEN

	A	B	C	D	E	F	Total of six men	Total of all men except F
1. Number of Ratings	261	261	234	203	80	169	1208	1039
2. Average Rating	99.9	100.9	101.8	101.6	101.5	100.1	100.9	101.0
3. Average % Error	4.67	5.34	6.12	5.62	5.28	4.86	5.32	5.40
4. Standard Deviation	5.93	6.21	7.66	6.77	7.06	6.42	6.65	6.67
5. Bartlett's test for homogeneity of variance "B/C"	64.26	55.65	59.72	42.36	34.19	70.26	21.46	21.38
6. Level of Significance	.27	0.61	0.54	0.48	0.02	0.0002	0.99	0.99
7. Analysis of Variance "F"	1.51	0.33	1.48	1.15	1.64	——	1.96	1.47
8. Level of Significance	.01	0.50	0.05	0.10	0.08	——	0.08	0.08

is close to normal, about 68% of them will fall within plus or minus one standard deviation and about 95% of the ratings will fall within plus or minus two standard deviations of the mean.

5. Bartlett's test for homogeneity of variance is made to see if, for the individual, the different loops are rated with about the same degree of variability. It tests for significant differences in the variances of the individual for the different film loops. The two columns on the right use the results of the ratings by the individual on all loops to test for different variances between men. The value B/C, obtained by calculation, is distributed approximately like the Chi-Square distribution.
6. The level of significance of the Bartlett's test is that level at which the computed B/C value equals the Chi-Square value obtained from tables of this function. The lower the level of significance, the more likelihood of differences between variances for different loops. In the case of man F, since the difference in the variance of the ratings for different loops could be ascribed to chance only two times out of ten thousand, it is considered significant.
7. The ratings assigned by one man to all loops are compared to see if he rates some loops significantly different from other loops. The F is the ratio of the variability of the man F or one loop to his variability from loop to loop. Man F showed evidence of having a significant difference between variances for different operations. The analysis of variance technique assumes that the variances are homogeneous. This assumption is false in the case of man F, therefore the analysis of variance would be meaningless, and is omitted from the table.
8. The level of significance is indicated by the approximate point at which the F in row 5 equals the F value obtained from tables of the function.

Table 4 shows the percent of the ratings made by each man that fall within definite limits on either side of the correct rating.

DISCUSSION OF RESULTS

The analysis of variance of the ratings made on the 63 film loops shows all men rated the loops alike with respect to the level of performance. It cannot be said that one time study man rated the individual loops any more nearly accurate than the others.

The test for homogeneity of variance is to determine if the differences in the variance of the ratings by the individual man for the different loops are due to chance, or if the difference is so great that it must be attributed to some other cause. Table 3 shows that for all men except man F the differences in variance could be due to chance alone. This indicates that level of performance and type of operation exhibited in the film loop had no effect on the variance of the ratings made by these men.

No positive explanation was apparent for the difference of man F in this respect, although a few possible reasons were found.

The analysis of variance determines whether the average of the ratings given by the time study man was closer to correct for some loops than for others. The average of all ratings given that loop was used as the correct rating. Table 3 indicates the difference between the converted ratings for different loops may be due to chance alone. Man A is on the border line at the one percent level of significance. No figure is given for Man F in this table, since his variances were shown to lack homogeneity. On the whole, the indications are that level of performance and type of job exhibited in the film loop have no effect on how close to correct the operation may be rated.

Table 4 shows that of the ratings, about 56% are within plus or minus 5% of the correct rating, and 74% are within plus or minus 7.5% of the correct rating.

This study indicates that ratings can be made with less variation from the correct rating than has been reported in some of the studies cited in Table 1. The observers used by Schell had all been trained to the same concept of normal initially, but there is no evidence that they had continued their training in the shop. They had worked in many different shops. The studies of Lockett, Ela, Mundel and Keim, and Lehrer had all used trained time study observers; but observers drawn from many different plants and industries. Careful mathematical corrections were made for the differences in concept of normal among the observers. However, the observers had not received similar training in rating, nor had they received periodic retraining. During the studies, the observers used the system of rating to which they were accustomed.

The average error obtained in this study is about equal to that obtained by Walters. In the study of Walters, all the observers came from the same company. Some were supervisors and some were time study men; but all received

TABLE 4
PERCENT OF RATINGS WITHIN DEFINITE LIMITS ON EITHER SIDE OF THE CORRECT VALUE *

Man	Within Plus or Minus 5%	7.5%	10%	20%	Total
A	61	80	92	100	100
B	53	71	87	99	100
C	50	68	80	99	100
D	51	72	86	99	100
E	63	74	83	99	100
F	62	77	89	100	100
Total	56	74	87	99	100

* The average of all ratings ever made on the film loop is used as the correct rating.

the same training program in rating. This involved five sessions of three hours each. The program trained the men to rate for a specific thing, speed or motion. Simple laboratory type operations or movements were used in this study.

The results obtained were not quite as good as those reported by Carroll. Carroll used motion picture films, and had the observers rate the films during many training sessions. Thus, the men received similar training, and had repeated opportunities to correct their ratings. Carroll concludes that it takes about 10,000 practice ratings for the trainee to reach a trained stage.

This study, the study made by Carroll, and the study reported by Walters all involved men trained to rate together, and men who participated in regular rating sessions. The men participating in the studies had opportunities to check up on their ratings, compare their performance to standard, and correct biases that might have been brought to light. This study and that of Carroll involved rating films, the study of Walters was made of ratings on simple operations actually performed by the men in the group of raters.

The other studies all involved men who had not been trained alike, although careful attempts were made to correct the data for differences in concept of normal among the raters. There is no indication that these men had the benefit of planned, periodic training in the technique of rating.

It is interesting to note that the company used in this study has very definite ideas about what should be rated (speed alone). The raters in the Walters group were taught to rate speed and Carroll also is an advocate of rating speed. The other experiments mentioned confined the rating to one factor, but the participants had not been previously taught to rate just that one factor.

CONCLUSIONS

1. Ratings of factory operations can be made with no significant differences between the level of the ratings from man to man, if the men are trained together and are familiar with the operations.

2. The standard deviation of independent ratings made by men trained together on operations with which they are familiar will be approximately 6.67 percent. Differences between the standard deviations of different men are so small they can be attributed to sampling errors.

3. Regular use of practice rating sessions reduces the error in rating and develops more consistency between men both as to variability of ratings and mean or level of ratings. Practice rating sessions should provide an opportunity for the men to check their ratings against the ratings of the other men in the group.

NOTE: 1. In trying to compare the results of this study with the results of

(Continued on Page 20)

TIME STUDY

(Continued from Page 7)

hardness and density values. This means that tensile strength can be used as the independent criterion for determining the accuracy of the estimates obtained from hardness and density values.

Unlike the variables in physical sciences, there is an inescapable dilemma involved in checking the accuracy of any rating procedure. The only independent criterion that could possibly exist is the time required by the hypothetical "normal" worker to perform a given operation. But if we knew this value, we would have no need to make a time study at all! Conversely, if we don't know this value, we can never determine how accurate the rating factors are.

To clarify these remarks, let us return to the tensile strength example. Here we can measure tensile strength, and the only reasons we estimate tensile strength values from hardness and density values are economy and ease. However, if we didn't know how to measure tensile strength, we could never determine how well tensile strength values could be estimated from hardness and density values.

Assuming, once more for argument's sake, that this dilemma could be resolved, another major problem would still exist with regard to the LMS leveling procedure. Let us assume that we had the independent criterion needed. The equation for estimating criterion values would have to be of the following form:

Independent Criterion = a(Skill) + b(Effort) + c(Consistency) + d(Conditions),

where the coefficient values for the factors depend on the relationships among them.

Now these coefficients can have values of unity only if the rating factors are independent of one another. But Lowry, Maynard and Stegemerten themselves admit this is not the case.[19] Thus, they state that "it is not customary to find a given degree of skill accompanied by an effort more than two classes higher or lower than the skill class, or vice versa." They also state that "operators of high skill usually work more consistently than less skilled operators," and that consistency "must be weighed in the light of the skill and effort of the operator." This means that the recommended procedure of simply adding the values for skill, effort, consistency, and conditions, (i.e., assuming that each coefficient value is unity) is completely unjustified. To handle this problem correctly, it would be necessary to compute the correct coefficient values by the appropriate statistical techniques.

It might also be mentioned that, even if an independent criterion could be developed, there would still be no way to establish the accuracy of a rating procedure. The explanation is much like that given with regard to the consistency of a rating procedure, for the results here also depend crucially on the observer. Consequently, we could speak only of the accuracy of an observer or a group of observers in using a rating procedure. Besides, if we were interested in more than one operation, we would have to make a study of the accuracy of one or more observers on each, assuming always that it is possible to develop the required independent criterion in each case.

Some critical students, notably Kennedy and Gomberg, have suggested that a "normal" worker can be defined quantitatively rather than subjectively. Thus, Kennedy recommends that a "normal" worker be defined in terms of quantitative average from the observed range of performance of a selected group of workers.[20] Gomberg has much the same viewpoint, contending that "the population concept from which a normal is to be derived must be related to the actual distribution of productivities as they exist, subject to some improvement in the low sectors of the distribution . . ."[21]

Though commendable, these suggestions would not solve the problem of accuracy since the dilemma mentioned above would still exist; the comments made on that subject apply regardless of how the "normal" worker is defined. Thus, while it is usually true that a quantitative definition is preferable to a subjective definition, there would be no need to take a time study if we knew the time value associated with the "normal" worker, no matter how defined.

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Project Progress Analysis and Control

(Continued from Page 3)

ent nature is found in the construction of a large process industry plant. This project extended over a period of nearly two years and was analyzed on the basis of budgeted dollars and labor hours. Close control was maintained on the various detail expenditures and progress reports were submitted and reviewed at frequent intervals by statistical, engineering and supervisory personnel. Figure 2 shows five curves of major elements of cost and one of actual labor hours worked. Inspection of these curves reveal the nature of progress of the typical elements of a project. For instance, the overhead costs (Curve No. 2) follow more nearly a straight line, engineering costs (Curve No. 4) rise sharply at first, with a long tapering off period, while the total costs (Curve No. 6) follow almost exactly a sine curve plotted from February, 1950 to the end of the project.

In a project extending over such a long period of time, small fluctuations will be smoothed out by compiling data on a monthly basis. However, these fluctuations will be relatively small when considered on an overall percentage basis.

Another, and even more detailed planning schedule than that indicated above, can be developed by using the Gantt Chart principle for the various steps or sequential operations of the project. For each operation's bar drawn on the time scale there can be indicated the number of man-days, for example, required at various stages of the operation. The man-days can be read from an appropriate design of the cumulative progress curve. Thus each stage of the project can be more accurately controlled, and more efficient utilization and coordination of man power, materials delivery, etc. will result.

Now to return to our question of how such curves might be developed. In most cases the empirical method will be used, although a theoretical approach is entirely possible. In the latter case the basic characteristics of project progress can be set up in a differential equation to express the relationships between time and percent complete at any stages of the project. However, the first method will be discussed here.

In connection with basic planning for a project, all available data should be utilized to establish standards and schedules. In cases of entirely new undertakings, estimates and judgment may have to be used, but in most organizations data are often at hand which are suitable, even though the data has not been "tapped" before. If additional data are required they usually can be obtained through normal channels of cost reporting and accounting, time study standards, labor records, periodic departmental reports, budgetary procedures, etc. It is a relatively simple matter to study historical records and plot expenditures, labor hours, etc. cumulatively against time. If this is done for a number of similar projects, a striking similarity in the shapes of the resultant curves will be noted in most instances. This simply means that a "habit" pattern has been developed in the company. This same pattern can be set up as a basis of control in future projects, with improvements and modifications as required.

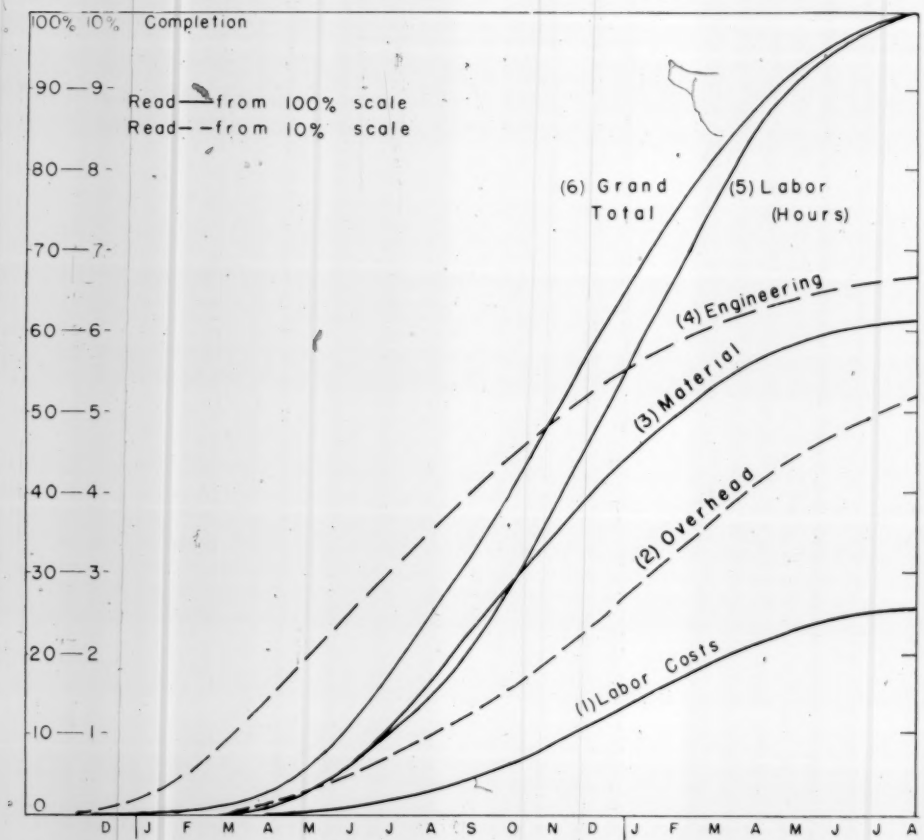

Figure 2

This last mentioned phase of the analysis should not be neglected. The analysis should evaluate the progress pattern with a view of improving the performance. Certain warning signs indicate points for investigation. First, large fluctuations from a smooth curve should be avoided. A change in rate requires larger expenditures of energy than maintaining constant "velocity." An analogy from the laws of motion can be applied here. Secondly, too long a time at the beginning in reaching normal progress rate (middle section of curve) and too long a tapering off at the end should be avoided. The actual rate of change or acceleration will have to be determined from each circumstance, but extension of these periods usually results in excessive overhead as well as other costs and also in psychological effects detrimental to morale. Undoubtedly, further analysis of the curves will reveal points at which further investigation may be indicated.

To summarize, then, the idea has been presented that, in general, progress on work of a project nature follows a curvilinear relationship between percent completion and time, that the shape of the curve will be similar for similar projects within an organization, that all curves will follow a general "sine" or "ogive" shape, and that planning and control of projects can be made more effective by use of such progress curves as described herein.

Book Review

MANUFACTURING MANAGEMENT
By Franklin G. Moore
Richard D. Irwin, Inc., Homewood, Illinois, 1953. 832 pages. $8.00

Prof. Moore has written an excellent book thoroughly covering all important phases of manufacturing management. He shows the interrelationships of the various functions and discusses the influence of organization and employee relations on the different manufacturing activities. He also brings in the historical background and the economic and political factors important to today's industry.

This extensive work covers administration and organization, facilities, products, employee relations and wages, time and motion study, quality and inspection, internal finance and accounting, materials, and production control.

RATIONALIZATION

By Per Edvin Amnell

This article was submitted for Mr. Amnell by Professor Ralph O. Swalm, Department of Industrial Engineering, Syracuse University, with the following comments:

> *Last year it was our privilege to have, as a candidate for a Master's degree, a Finnish student, Per Edvin Amnell. As a part of one of his term papers, he included the enclosed discussion of the word "rationalization," as used by our European contemporaries. Since I find that we, in this country, almost invariably associate the word with its psychological meaning; i.e., "to attribute (one's actions) to rational and creditable motives without adequate analysis of the true motives," it occurred to me that this discussion might be of interest to our broad membership.*
> *I am therefore submitting it to you for consideration for publication in our Journal of Industrial Engineering. Since such slight errors in English as appear add more to the charm of the paper than they detract from its readability, I am submitting it exactly as written.*

At an economic conference, held in Helsinki, Finland, in February 1953, a Finnish expert on economics made among others the following statements (translated from Finnish):

"As compared with the big need for investments there is a shortage of capital in our country. The resulting high interest rate makes the production, and the rationalization of production more expensive. At the same time the high cost of money retards the renovation of equipment and manufacturing facilities."

"Through rationalization and other measures the cost per production unit has to be decreased."

In current economic statements and comments on economic conditions in many European countries the words "rationalization," "to rationalize," appear frequently. This is particularly true when the writer criticizes present conditions and makes proposals for improvements.

To European economists and engineers the meaning of the words is usually clear and does not cause any misunderstanding. The American meaning seems however to be somewhat different. As the British conception is the same as the European in general the term English cannot be used in this context.

Because of the importance, and the wide use of the terms in Europe, this paper attempts to clarify them to an American reader. Thus, the words "rationalization" and "rationalize" are in the text used as an European engineer would use them. The reader can from the context derive the meaning from case to case and finally end up with a picture of what is included in the terms. A simultaneous thinking of the appropriate American term would add to the value of the comparison.

THE MEANING OF "RATIONALIZATION"

At a world economic conference, held in Geneva, Switzerland, in 1927, the following definition of "rationalization" was agreed upon (translated from Finnish):

"Rationalization means a scientific arrangement of work, standardization of materials and products, improvement of transportation (materials handling) and distribution."

The concept of rationalization has been developed since the time of the definition above. Nowadays it implies a continuous, or at least systematic activity, which, using the means of science, technique, and cooperation, aims at increasing the economic yield of the production, and its human attractiveness. Production means in this context organization, physical facilities, and human effort.

Rationalization is, or can be directed toward the economic life in general, such as political economics or economic policy, or toward sections or parts of it. Examples of these would be, for instance, organization and management of manufacturing, transportations, labor relations, production facilities, products and materials.

The concept of rationalization can be defined in different wordings but the fundamental thinking remains the same: "A strive by means of science and technique to avoid a wrong and wasteful use of not only materials and time, but also human effort." The goals of rationalization are thus nothing very new, but so are however the methods now in use.

As was said above, rationalization has to be a continuous or systematic activity. Thus, for instance, an invention as such is not rationalization, but the installation of it in a plant, with subsequent changes might well be it. Rationalization, to be it in a deeper meaning, has to be a systematic study of all factors affecting a situation, and a systematic realization of the appropriate measures as a result from the study.

The use of science and technique means to free oneself from personal prejudices, and base the action only on what can be considered as reliable facts.

The primary object of rationalization is an increased efficiency (yield) of the productive activities. However, the deepest goal of rationalization is an increase of the prospects of human happiness. This cannot be achieved by considering only materialistic factors. It is equally important to attain a state where the performance of work can take place in such a way that it is connected with a happy and enjoyable life.

Thus, some of the most difficult problems of rationalization is the problem of the human being and the work. The materialistic factors, such as materials and equipment, can usually be controlled by technical computations. So, however not the human factors. This is the reason for the increasing importance and recognition of the application of the science of physiology and psychology when the objective answers are search for to the human problems of rationalization.

The originator of what is now called rationalization in Europe is Frederick W. Taylor. The first basic principles were presented in his work "Principles of Scientific Management." With this as an additional background rationalization could be regarded as a modification and expansion of the original theory, and could then maybe defined as "introduction, application, and maintenance of scientific management to every phase of economic life."

This scope is without doubt gigantic. It is one of the reasons for stressing the importance of cooperation. Without cooperation only little can be achieved.

But rationalization concerns every section of economic life. Industrial Engineering makes a very definite contribution to it. It is a prominent part of rationalization. Methods studies and methods improvements are a part of industrial engineering. When a layman in Europe meets the word rationalization, his first thought is methods improvements and work simplification, frequently combined with some degree of mechanization. This report is concerned with rationalization in the form of methods study and methods improvements, and various techniques used in this work.

The technique of rationalization is a combination of analysis and synthesis. The present conditions are first investigated thoroughly. Contributing factors are divided, possible according to various viewpoints into subfactors. The interrelationships between these and their effect on the object for the study are next investigated.

Through variation of the subfactors new systems are created, the potentialities of which are compared one with another. The arrangement best suited for the whole purpose then chosen.

This way of working through analysis and synthesis is common in all scientific work. It maybe does not result in as ingenious solutions as can be the result of the brilliance of an inventor, but it gives sure and definite results. These are normally the result of teamwork between many people who represent different fields and together provide for a wide knowledge and experience.

GENERAL APPROACH TO A RATIONALIZATION OF A COMPANY

The following discussion of the approach to the rationalization of a manufacturing company can be regarded as based on assumption that the enterprise has no industrial engineering function on its organization, and that the application of the principles of scientific management has been comparatively limited.

It would be the approach of a consulting, or newly hired experience indus-

trial engineer. The main goal is to improve the over-all efficiency in the company. It is evident that the engineer must be fairly well acquainted with the various phases of the activities within the company. Economic aspects are of fundamental importance.

The first task is a **general survey** which could be called an inventory of **"rationalization potentiality."** The revealed potential objects for rationalization are next studied in a cursory way and combined into a **general plan of action.** This includes frequently ignition (or proposals for improvements) of, for instance, production planning, production control, purchasing, cost accounting, training programs, etc. Often the introduction of work study (industrial engineering) constitutes a significant part of the plan.

The making of the general survey and the general plan of action is not discussed in detail in this paper. It is however useful to know, that these precede the actual work study.

Assuming that the proposed work study is approved and the appropriate industrial engineering function is installed the next step is going to be presented.

It is obvious that it is necessary to get an over-all picture of the situation before any details should be attacked. Therefore, the task for the industrial engineer is to make a thorough **study of the organization of the company.** The object of the study is the whole company (or plant or factory) including administration, management, cost accounting, purchasing, production planning and control, distribution, and storage. When this study is completed and the general picture of the coordination and cooperation between departments is derived many opportunities of increasing efficiency are normally revealed. The application of the study and the realization of the consequent improvements is called **general rationalization.** When the smooth cooperation between the departments is achieved the industrial engineer can proceed planning the actual work study in detail.

This starts with a study of the manufacturing process. It is usually advisable to begin the study at the end of the process, for instance, in the assembly department. Thus any errors made in the preceding operations are better revealed, and are in addition easier to avoid when their effect is known later on. At this stage no attention should be paid to prevailing or eventual incentives. Many mistakes were made in the early times of rationalization when incentives were connected with the studies at a too early stage of the procedure.

If the study is started at the beginning of the process methods might be devised which do not take into consideration the influence on succeeding operations. When the later phases of the process are studies these methods might have to be changed a second time, and this should of course be avoided by a correct order of procedure.

When all departments are studied it becomes clear which work places provide for the largest potential savings. The notes and observations on these are made especially accurate so that they can be used for the actual work studies.

The first improvements have naturally to be concentrated on the most uneconomical objects. It is important to know the various components of costs and their significance at each stage of the process. The work study man has to make himself familiar with this already at the preparatory stage of the rationalization work.

When the general rationalization is made along the lines described above, taking the whole scope into consideration, but at the same time analyzing details, a good foundation is laid for successful work studies.

Consistency In Speed Rating

(Continued from Page 17)

ratings made in the shop, keep in mind that in effect, the ratings used here are as if a man took a look at an operation, gave it one rating, then six months or a year later saw exactly the same operation and gave it one rating, and so forth. He might be expected to do better if he rated several operators or rated the same operator several days in a row, or if several men rated the same operator.

2. Records of the type kept by this company provide an invaluable source of data. For example; if punch cards were used, it would be possible to sort out ratings made by any man on certain types of operations, or on males vs. females, or at certain speeds, or at different times of the year, or many other combinations.

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PRESIDENT'S MESSAGE

(Continued From Page 2)

Vice-President of your region should go to your present regional vice-president (see Section 13 above). (2) Nominations for other National Officers to E. L. Slagle, Jr., Vice-President, Western Region, Columbia—Geneva Steel Division, U. S. Steel Corp., Pittsburg, California or may be transmitted to him through your own regional vice-president. Ed Slagle has been appointed as Chairman of the Nominating Committee of vice-presidents as contemplated by Section 12 (above) of our National Constitution.

There are two important ways for you to support the National Convention at Louisville, Kentucky in May. First, send immediately to the National Convention Chairman, Stephen A. Derry, Kentucky Home Life Building, Louisville 2, Kentucky, suggestions as to speakers and/or subjects. Second, start planning now to be there, you need the convention and the convention needs you.

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Evolution of an Industrial Engineering Program

By Robert S. Lynch
President, Atlantic Steel Company

Based on an address to The American Society for Engineering, Education, Annual Convention, Gainesville, Florida, June 24, 1953

In talking to you about Industrial Engineering practices in industry, it is natural and proper that I speak primarily of the steel industry, and, more specifically, of Industrial Engineering at the Atlantic Steel Company. Atlantic Steel's Industrial Engineering problems are typical of those in the steel industry. Yet, the practices used in solving these problems differ in many respects from standard practices in the industry. Atlantic Steel is small compared to the giant plants typical of the large steel producers. Its existence, competitively, is based on its ability to remain flexible, to produce diversified and specialty products, and to provide specialized customer service. Its 300,000 ton annual capacity is less than three-tenths of one percent of the industry's potential. Yet within the confines of Atlantic Steel's 190 acres, its 2300 employees perform nearly all the variety and complexity of operations performed by employees of the larger steel producers, excepting, primarily, those involving blast furnaces and rolling facilities for sheets and plate.

Because of this, Atlantic Steel's five Industrial Engineers face the same variety and complexity of problems that are prevalent in larger plants. Crammed within the personalities of these five individuals must be the wide variety of talent, educational background, and experience that can be spread out among the larger number of individuals of the Industrial Engineering staff of a big steel company. Versatility is more important in small companies.

There are other fundamental causes for differences in Industrial Engineering practices between Atlantic Steel and the industry in general. Small companies can enjoy a luxury of informality in management that is not available to its larger counterparts. Strict rigidity in practices and procedures can give way to flexibility in handling non-conforming problems. Small companies stay closer to their human problems and can give them more consideration in the solution of their industrial problems. Employee pride, cooperation and teamwork are the strongest assets of a small organization. Consequently, Atlantic Steel's Industrial Engineering practices have become tempered by versatility, informality, flexibility and human relations so that they differ in many respects from the standard practices of the steel industry and of other industries.

I feel that my talk will be of more benefit to this group if I spend more time in discussing the Industrial Engineering field wherein Atlantic Steel differs from rather than conforms to standard industrial practice. My reason for this is two-fold:

First, all of you here are intimately familiar with the general practices in industry from your long experiences in the fields of Engineering Education. Second, some of our differences in practices have provided a rather unique solution to general problems in industry. Creative thinking and discussion about these practices may lead the way to better use of Industrial Engineers in industry.

Please understand that although I tend to emphasize the differences in practices, our concepts of objectives, fundamentals and uses of Industrial Engineering are similar to those adopted by industry in general. These concepts have been well expressed by Col. Frank Groseclose, Dr. Bob Lehrer and James Galey of Georgia Tech in their recent article published by SOUTHERN POWER AND INDUSTRY (June 1953).

We consider Industrial Engineers as primarily concerned with methods — methods of planning, organizing, coordinating and controlling machines, materials and men to attain greater productivity for the benefit of employees, customers, stockholders and the general public. Starting with the techniques of time study and standardization originated by Taylor at the turn of the century and motion study developed by the Gilbreaths, Industrial Engineers have been able to apply scientific principles to the direction and measurement of human effort. The skill and effort of human operations has been geared to the precision of machines. Industrial Engineers brought into industry the concept of "scientific management" which is to apply a systematic approach to the variety of problems in the management of the shop and of the enterprise.

Industrial Engineering was started at Atlantic Steel in 1937 to apply these concepts to a small company expanding its operations after a period of relative inactivity during the depression years. During the first five years of existence, the new department established itself as a permanent part of the Company organization. In this period our Industrial Engineers maintained strict compliance with the accepted practices of the industry.

1. A "job engineering" approach was used in the establishment of new jobs and in the revision of old jobs. Motion and time study was used to develop the best method of utilizing men, materials and machines to attain the highest productivity.

2. Written standard practices were adopted and published to maintain uniformity and standardization of operating procedures and practices.

3. A wage incentive system was installed. It was based on the Bedeaux plan and conformed to standard Industrial Engineering practices.

4. Reporting and control procedures were established whereby management could measure and control the human performance in those departments where the incentive plans were installed.

5. A point system of Job Evaluation was used to establish and adjust base rates so that wage differentials reflected true differences in job content.

During this period from 1937 through 1942 all of the Industrial Engineering time and energy were devoted to job methods, work assignments, wage incentives, job evaluation, and materials handling problems through practices that conformed with industry standards and with which you are well acquainted. In 1943, the activities of the Industrial Engineering Department were drastically reduced — not because of failure nor because of lack of faith by management or employees — but because the entire personnel of the department had been called to active duty with the armed forces. Although the Industrial Engineers were away in service during the war years, their fundamentals and practices were well founded and continued in practice during their absence. A firm foundation had been laid for the expansion of Industrial Engineering activities and the extension of incentive plans throughout the plant immediately after the war.

Upon the return of the Industrial Engineers from service in 1946, the department was expanded on the basis of the fundamentals and practices that existed prior to the war. The work of the group was intensified and wage incentive plans were extended, it being the intention of management to provide incentive opportunity to all its production, maintenance and service employees. In so doing, Industrial Engineers began to become involved in a problem — the human problem.

The human problem is not a new problem — it was merely overlooked during the industrial period when management erroneously thought of workers as little more than machines that had to eat. It is not a local problem — it is faced by Industrial Engineers nation wide. It is not a minor problem — the American Institute of Industrial Engineers devoted its annual conference in May to the theme of Industrial Engineering in Labor Relations. The human problem arises within the Industrial Engineer's responsibility of controlling and coordinating machines, materials and men. Machines and materials can be controlled within

close tolerances. They react uniformly to the application of funamental principles. Men do not.

There is a wide variation in the personalities and capabilities of individuals. Our Creator apparently did not use blueprints with rigid specifications and close tolerances in the production of individual personalities. While the resulting variety may provide the spice of life for society, it makes difficult the control of human performance in the manufacturing industries. Just as inspection of quality — from the standpoint of segregating the good from the bad — does not control the quality of the manufactured product; neither does the measurement of human performance provide the control of human performance necessary to coordinate men, materials and machines to attain maximum productivity. Industrial Engineers need to dig deeper into the assignable causes of variation in human motivation.

Workers' philosophy has been changed during the past twenty years. Just as the value of the dollar has been reduced, so has the value of financial incentive been reduced as the chief factor in human motivation. Surveys of workers in modern industry show that human treatment and dignity are more important to them than high pay. Happy workers are good producers; the chief cause of low productivity is unhappy workers. Quoted from TIME magazine of Apr. 14, 1952 is the statement by Clarence Francis, General Food's Chairman: "You can buy a man's time, you can buy a man's physical presence at a given place; you can even buy a measured number of skilled muscular motions per hour or day. But you cannot buy enthusiasm; you cannot buy initiative; you cannot buy loyalty; you cannot buy the devotion of hearts, minds and souls. You have to earn these things . . . It is ironic that Americans — the most advanced people technically, mechanically and industrially — should have waited until a comparatively recent period to inquire into the most promising single source of productivity: namely, the human will to work. It is hopeful, on the other hand, that the search is now underway."

Industrial Engineers have a responsibility for increasing productivity by developing the human will to work. Industrial Engineering cannot be divorced from "Human" engineering. In working on problems of variation in human performance and of developing human motivation, it is natural that Industrial Engineers must cross over into other functions that deal primarily with human problems. It seems inevitable that the fundamentals and principles of Industrial Engineering should "lock horns" with some conflicting fundamentals and principles of the Industrial Relations and Personnel Departments. Actually, in many companies there has existed a professional jealously and animosity between Industrial Engineers and other management functions that attempt to accomplish the same objective by different means.

Industrial Engineering at Atlantic Steel Company was fortunate that it was able to incorporate the principles of human relations into its program without the long period of conflict with the other personnel functions. Because of the versatility of talent in the Industrial Engineering group, because of the informality in management of a small company, because of flexibility in practices and procedures, and because of Atlantic Steel's keen interest in the human problem, our Industrial Engineering practices have been tempered to conform to the basic Company policies of human relations.

The very nature of human relations demands that Industrial Engineers be allowed flexibility and originality in their work so as to conform to the human aspects of each problem. At Atlantic Steel, they are allowed complete freedom in the design and application of new incentive plans so long as they conform to the fundamental principles of incentives. Although consistency in type incentives is attempted, Industrial Engineers are not obligated to conform to existing types in determining the measure of productivity to be used, and the proper placing of the incentive, in determining the methods to be used or the type and number of time studies to be made. As a result, the various departments in the plant do not have the same type of incentive plan; neither did the various departments have the same type of problems in safety, quality, costs, production and human relations. While there may be complexity and, in some cases, confusion because of the wide variety of incentive plans used, each plan has been designed to accomplish specific purposes in meeting the demands of operations and yet adhering to the fundamental principles of incentives.

Good relations with employees demands that there be complete trust and confidence between Industrial Engineers and workers. All Industrial Engineering studies or data are available for study by any person concerned. There are no secrets. Further than that, Industrial Engineers discuss freely with workers on the job concerning the problems, intentions, possible courses of action and probable results. Employee suggestions and participation in all phases of the project are encouraged.

Incentive opportunity for emloyees is not limited because of the nature of their jobs. The company attempts to provide the same incentive opportunity to all production and maintenance employees. Machine operators with enforced idle time are given the same incentive opportunity for maximum production as are other workers with balanced work loads and no enforced idle time. Group incentives are used in a large number of steel mill operations which depend on the cooperative efforts of the group. The same incentive basis is used to pay all members of the group even though the work load of some is greater than that of others. Differences in skill and responsibility are recognized by base rate and tonnage rate differentials. There is no hesitancy to use average earnings as a basis of pay while incentive opportunity is temporarily denied due to changes in methods, processes, machines or materials.

Industrial Engineers work continuously with supervision and workers after the installation of a new incentive plan in order to assist in training, scheduling, materials handling, employee motivation, and other problems so that the workers make their expected incentive earnings. The design and installation of an incentive plan is only half of the job; the important half is making it work after installation. Many a good incentive plan has failed because of poor follow-up; many a mediocre plan has been successful because of good follow-up.

These few Atlantic Steel Industrial Engineering practices, that I have just mentioned, represent some deviation from standard practices of industry which are caused by our consideration of the human problem. Far more noticeable has been the injection of Industrial Engineering techniques and principles into the other functions normally associated with Human Relations.

Industrial Engineers have become more and more involved in plant bargaining and negotiations with our Union not only over rates of pay and incentive plans but also over related problems of promotions, qualifications and capabilities of employees, and work assignments resulting from the establishment of jobs and incentive plans. The interest in plant safety by the Industrial Engineers and the originality of their ideas in developing safety programs and topics for general plant use has caused this group to be given a leading part in designing and presenting the safety program at the monthly plant-wide supervisory meeting devoted exclusively to safety. Industrial Engineers have contributed their services to the work of our Accident Prevention Committee.

Because of their original work in developing supervisory and employee training programs, the Industrial Engineers were given the assignment of organizing and staffing a Training Department which operated under the Chief Industrial Engineer. The work of Industrial Engineers became so intermingled with that of the other departments dealing with Human problems that all of these departments were "alloyed" together in October of 1952 under the direction of the former Chief Industrial Engineer. Thus the functions of Employment, Personnel, Safety, Training, Industrial Relations and Industrial Engineering have become united to operate together as a single team — a team whose primary function is concerned with methods of planning, organizing, coordinating and controlling machines, materials and

MEN to attain greater productivity—a team that can measure and control the assignable variation in human performance from the time of employment until the time of retirement on pension—a team that can develop "the most promising single source of productivity; namely, the human will to work."

It might be well at this point to disregard the past and the present to look ahead to the future trends of Industrial Engineering at Atlantic Steel. Two new concepts are coming into prominence, and since they pertain to the individual qualifications and educational background, your group in the field of Engineering Education can do much to help industry in these problems. The first concept needed by Industrial Engineers in Industry is that of "hyphenated-engineers" as expressed by Mr. Harry Lee Waddell in the February 1953 issue of FACTORY MANAGEMENT AND MAINTENANCE.

It is true that we live in an age of specialization, but specializing can be carried too far. In the extreme, specializing means learning more and more about less and less subjects until, eventually, you know everything about nothing. Generalizing in the other extreme means learning less and less about more and more subjects until, eventually, you know nothing about everything. Somewhere in between there is a happy medium. The present trend on the part of our Industrial Engineers is toward more versatility — even to the extent of crossing over into other recognized professional fields.

A recent problem at Atlantic Steel concerned the method of handling hot ingots from our new electric furnace to our soaking pits for reheating and subsequent rolling. To the Industrial Engineer assigned to the project, what started out as a simple materials handling problem wound up as a complex problem involving melting practices, scheduling, metallurgy, chemistry and heating practices as well.

In our Industrial Engineering Department we are trying to broaden the knowledge of our engineers to cover additional fields, particularly safety, training, quality, control, human relations accounting and some mechanical, electrical, and metallurgy so that we have talent available to handle any project even though it involves crossing traditionally specialized fields.

The second concept needed by Industrial Engineers in industry is that of "Imagineering in Management." "Imagineering" is a coined word taken from a textbook on Industrial Organization and Management. It means "using your imagination based on sound engineering principles." All of us are well aware of the miracles of "imagineering" in developing new products new materials, new machines and new processes. Television, atomic energy, jet aircraft, machines that think, automaton production lines, — all represent areas wherein the wildest imagination of two decades ago has been engineered into actual being. But management has not kept pace in the imagineering in human relations. To achieve greater productivity by developing the "human will to work" will require the same creative thinking and originality used by engineers in the development of new products, machines, methods and materials. Industrial Engineers must take a leading part in imagineering new concepts of dealing with people.

It is difficult to visualize new concepts in dealing with people beyond that given to us in The Golden Rule. Perhaps the way may be opened by a story told by Bill Levy, Educational Manager of the National Association of Foremen. Bill's job requires him to visit quite a few plants and, as a visiting celebrity, he is generally taken on a tour of the plant:

"Most plant managers are proud of their plants. They take great pride in showing new equipment and new machinery that cost large sums of money and that produce at astounding rates of production. They speak lavishly of the accomplishments of the machines, but fail to recognize the human operators of the machines, without whom such production could not be accomplished. These plants have the usual problems of human relations. But there was one plant that had a noticeable improvement in attitude. It did not have the human relations problems so common in other plants. The plant manager had a different approach. In his tour through the shop he didn't emphasize what the **machines** could do, but rather he bragged about the great production and high quality the **man** could produce **using** the new machines. Typical of this manager's attitude toward his men was his approach to the freight elevator in the back corner of the shop. He introduced his visitor to the operator with the words: "I want you to meet Tony ————." (I can never remember Tony's name, and couldn't pronounce it if I did). "Tony has operated this freight elevator for twenty-five years and has never had an accident. This Company is proud of Tony's record." Tony beamed.

"A quick examination of the elevator showed that an accident would be next to impossible. With Tony on the job, it would be impossible. Most freight elevators are, at best, pretty dirty, dingy and unkept. Not Tony's. His was spic and span and sparkled with spit and polish. Prominently displayed was a large frame bearing the title "Safety Regulations." Listed underneath were more than the usual rules of capacity; these rules covered all points of safe operation and safe conduct of riders. Most significant of all was printed at the bottom of the sheet "by Tony ———" and his title "Superintendent of Perpendicular Transportation."

You will never be able to evaluate into that job title all the pride, the interest, and the job satisfaction that was given to Tony — given to him through imagineering in management.

SUMMARY

In conclusion, may I summarize the main points of our Industrial Engineering practices at Atlantic Steel Company.

1. The fundamentals of Industrial Engineering at Atlantic Steel are the same as those adopted by industry in general.
2. Atlantic Steel's Industrial Engineering practices have become tempered by versatility, informality, flexibility and human relations so that they differ in many respects from the standard practices of industry.
3. Our Industrial Engineers became involved in the problem of human relations and developed a unique solution whereby Industrial Engineers became "alloyed" with other functions dealing with human problems, making a stronger team to control human performance and develop the human will to work.
4. Industrial Engineers need help in developing the new concepts of "hyphenated-engineers" and "imagineering" in management.

TECHNICAL REVIEW OF STATISTICS

by Dr. James R. Jackson
University of California, Los Angeles

"I Would I Were . . ."

I would I were a random sample —
Not too small and not too ample;
But just of economic size,
Expected gains to maximize.

◇◇

I'd want my mean to be just so —
Not too high and not too low;
Variance small to fit the goal
Of proving things are in control.

◇◇◇

But most of all I'd want my plot
Smooth and bell-shaped, to the jot;
Then with theories pure and formal,
I'd conform, for I'd be normal.

DISTRIBUTION OF ENGINEERS

Branch	1940*	1950†	% Increase
Civil	105,500	124,600	18
Electrical	55,700	93,400	68
Mechanical	85,500	98,600	15
Industrial	9,800	46,700	376
Metal. & Mining	9,800	25,900	164
Chemical	11,600	31,100	168

* Data from U. S. Census Bureau letter Series P-44 No. 1 February 1944, Comparative Occupation & Industry Statistics 1940 and 1930 (Engineers were not reported by branch in 1930 in sufficient detail to permit comparison.)

† Data from 1950 census preliminary data published by Engineering Manpower Commission March 1953.

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Book Review

"SUCCESSFUL LABOR RELATIONS FOR SMALL BUSINESS,"

By James M. Black and J. George Piccoli,

McGraw-Hill Book Company, Inc., New York, 1953, 425 pages, $6.00

Black and Piccoli have chosen the personal viewpoint of a small business man dealing with employees and their union representatives. This results in an eminently readable book with many practical points against a background discussion of union strategy and tactics, goals, internal politics and organization.

A noteworthy feature is a clause-by-clause case history of an actual contract negotiation with the reasons for each step and the possible pitfalls. The authors also discuss organizational drives, strikes, NLRB procedures, and arbitration. The authors also include a statistical report on the current personnel practices in the Cleveland area.